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ENGINEERING

An Illustrated Weekly Journal

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ENGINEERING

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Leading Article
Two Worlds 385

Plain Words 386

Weekly Survey 389

Principal Articles
New Designs at Geneva Motor Show 386
A Full Life for Students at Imperial College 391
Airliner Accidents 392
Chemical and Industrial Glassware 393
Component Shaping by Flame Gouging 394
Inspection of Profile of Surface: Large Dual-Capacity Projector 394
Rationalised Die Castings: Output Increased and Damage Reduced 395
Canadian de Havilland Design for Troop Carrier 396
Testing DC7-C's Cabin Pressure Instruments 396
Frozen-Stress Techniques: Three-Dimensional Photoelastic Stress Analysis 397
Advanced Reactor Systems
Fast-Thermal Reactor: Two-Region Critical Assembly for Breeder Studies 404
Induction Melting Furnace: Mains Frequency, Coreless Construction 406
Microwave Beacon for Fishing Vessels 407
Indicating Smoke Density 407
The Future Lies in Heavy Lorries 408
Micro-Adjustment of Milling Cutter Width 409
Pushing, Pulling or Indexing: New Compressed Air Equipment 409
Removing Taper Shank Tools 410

Letters to the Editor
Galling of Titanium 388
Temperatures in Brake Drums 388
An Engineer's Card Index 388
Jaguar Fire 389

Book Reviews
New India's Rivers 402
Boiler Plant Instrumentation 402

On the Shelf (Libraries and Information) 403

New Books and Trade Publications 403

Notes
Training for the New Diploma of Technology 391
High Salaries for Arts Graduates 392
Another Way in Which Firms can help the Colleges 392
Developments in Paint Materials 393
Aluminium " Apron " for Oxford Playhouse 393
Low-Grade Fuels for High Speed Engines 394
Fish-Finding from a Helicopter 395
A.C. Installations for Marine Use 396
Adjustable Racks 406
Pneumatic Control Valves 406
Thin-Walled Bearings in Large Sizes 407
Building Material Data 407

Atomic Review
A Few Golden Apples 411

Notices of Meetings 410

Forthcoming Exhibitions and Conferences 414

In Parliament 415

The Human Element 416

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TWO WORLDS

SOME of the wide-awake men in industry are looking beyond the dispute in the engineering and shipbuilding industries—they are looking to the prospect of sweeping away one of the root causes of conflict, so that the threat of widespread strikes in the future will be lessened.

It is a tale of two worlds: the two worlds inhabited by employers and employees. Take the case of the managing director of an expanding engineering firm making products that have a bright future. His life is an absorbing round of interviews, visits, lunch and dinner appointments, negotiations, meetings and travel. He is constantly reading, discussing, weighing up imponderables, exercising his imagination to its limits, sifting all kinds of data, planning ahead and dealing with day-to-day issues. He is moving swiftly along in the stream of contemporary ideas and action. His work is his vocation, to which he is dedicated and compared with which everything else is of secondary importance. True, he sometimes puts his head in his cupped hands in a moment of despair, but it is only an occasional reaction from the relentless pressure under which he works. The moment soon passes as he talks to his research chief and hears of the exciting possibilities of some new line of investigation. When his sales manager cables a spanking order that he thought was beyond their reach his confidence in the firm's basic success is once again confirmed.

Contrast this with the life of a man in the shipyard or the workshop. Except for an occasional change of job and, if he is middle aged or older, the memory of a time when he was without a job, he exhausted the variety of his work while he was still a young man. If he is a man of character, he will take a pride—almost an obstinate pride—in the microcosm of shipbuilding or engineering for which he is responsible. Being a private in a vast army he is never permitted a glimpse of the overall strategy. His conception of industrial affairs, outside his own limited experience, is formed by the mass media of news and entertainment. As the policy of these mass media is far from altruistic but is based on the various commercial interests of the proprietors, his understanding of industrial affairs is about as near the truth as an adolescent's understanding of love as he watches a Hollywood film.

These are the two worlds: the employer and the employee—each in his own, cut off from the other. In normal times this separateness causes no great difficulty; each man carries on with his own work, the man on the shop floor knowing even more clearly than the manager exactly what is expected of him. It is not surprising that when a labour dispute arises the reactions of the two differ widely. The employer, with his background of intense activity and aspiration, buoyed up by the thought of future plans and the excitement of putting them to the test, regards a strike as sheer folly, damaging to both parties and an act of sabotage to the enterprise which can bring new prosperity to everyone. He finds common cause with other employers (normally his competitors!). The swift change of atmosphere confuses the employee even more. From working to a routine that he has long ago mastered, he passes into a realm of ideas that he only vaguely comprehends, and for which his education and experience have left him totally unprepared. He is prey to all the influences that dramatise the situation and he is naturally predisposed to the newspaper or trade union official who seems to have most sympathy with him.

When this state of hostility has been reached it is useless to examine the words uttered by both sides. Though the arguments conflict they sound not unreasonable, taken individually; they are, in fact, based on each side's reasoning. To make sense of the conflict it is necessary to look behind the words to the inconvenient but inescapable fact that the employer and the employee live in their separate worlds. For if this isolation of each from the other can be ended, or at least reduced, there will not be the same tendency to adopt a defensive or aggressive attitude at the slightest sign of a dispute. And the only way is somehow to imbue the employee with that sense of vitality that the employer enjoys automatically.

No one has really tackled this problem. Works magazines, profit-sharing schemes, works councils, presentation of the company's financial information to employees and the like are all very fine (though they are still not universally adopted), but something more fundamental is needed. We have made inquiries to see if anyone has done anything in this direction, but we have drawn a blank. We did find, however, that a small number of people in management are thinking on these lines. What will these thoughts lead to? They must surely lead to a system which provides a flow of information to all employees—information on all kinds of topics which are normally regarded as of concern to managers only. The employee, who has to abide by the decisions of the employer, should enjoy some of the enlightenment which enables the employer to make the decisions. He cannot visit overseas markets, or spend hours talking to research workers, but by means of films or any other suitable medium he could become informed

about the whole web of industrial affairs in a way that would dominate his thinking and protect him from the chance effects of outside and irrelevant influences.

It is no use looking to the trade union officials for a lead in this direction. They might well have a sincere desire to see such a development, but they themselves are no longer on the shop floor—they are caught up in a world that is just as enthralling and not unlike the employer's world. No, if anyone is going to pioneer in this field it will be a go-ahead company.

* * *

Plain Words

Taxation is crippling United Kingdom shipping. For ten years now there has been a decline in the world importance of the British merchant fleet. In desperation owners are considering the possibilities of Bermuda as a place where they might compete on equal terms with owners whose fleets are registered under "flags of convenience;" in other words, countries where they pay no tax. Liberia, with virtually no shipping before the war, now ranks as the fourth largest shipowning country with 6½ million registered tons; Panama has a tonnage of over 4 million.

The drain of taxation takes two forms. First, ships have to be replaced largely out of taxed income. Second, taxation on operating profits makes the investment most unattractive. Facts and figures to support these statements are given in the annual report of the Liverpool Shipowners' Association, published last week. For example, a cargo liner built 20 years ago for £250,000 will now cost about £1·4 million to replace. But since depreciation allowances are related to first cost, only £250,000 will be allowed under the heading of "wear and tear." The investment allowance of 20 per cent. on the cost of the new ship provides a further £280,000 exempt from tax. Thus £870,000 will have to be found from taxed funds. The report states that the replacement of such a ship effectively requires "earnings in excess of £2 million . . . without taking into account the needs of servicing of capital and maintenance of confidence on the part of investors, which are essential needs of a continuing business."

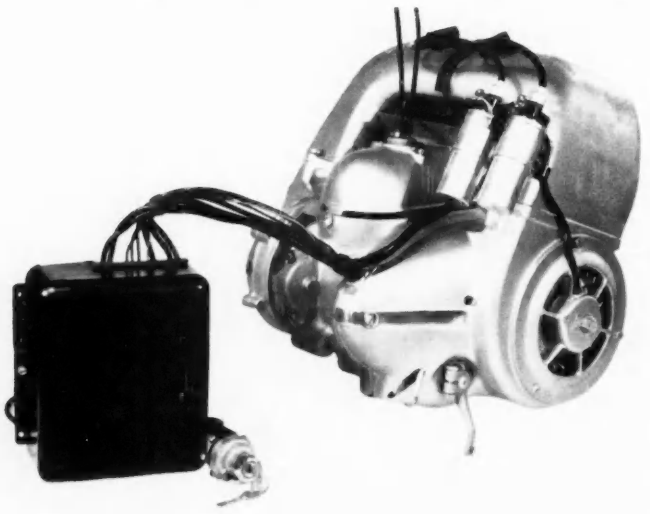
An alarming state of affairs is revealed by the shipping statistics: only 20 per cent. of the liner tonnage on United Kingdom register at mid-1956 was built in 1937 or later. Yet evidence abounds that old ships cannot compete with new. The large modern fleets of "tax free" flags will in time drive British ships from the oceans. It is to the shame of post-war Governments that they should have caused such erosion of a unique asset. The Treasury sometimes gives its consent to the transfer of fleets to Bermuda. But this kind of thing should not be necessary. British shipping needs not a subsidy but, firstly, more investment allowances, secondly, the assurance that these will not be reduced and, thirdly, as the report states, freedom from tax of those sums "set aside for shipbuilding and used as such."

NEW DESIGNS AT GENEVA MOTOR SHOW

By Gordon Wilkins

Each year the British motor industry stages a major sales effort at the Geneva Motor Show—this year it is again the largest exhibitor—but so far the sales figures give no sign that it is winning back its lost lead in this important international market. The leading place we gained after the war was lost partly by continuing too long with ugly and indifferent cars, and partly by giving up too easily when other markets seemed more attractive. The problem is now as much one of style and salesmanship as of engineering, but competition in technical developments remains fierce. The Germans are working hard to cancel our lead in aids to easy driving on small cars, and the public here in Switzerland is being led to expect rapid developments in suspension design following the adoption of self-levelling hydraulically-damped pneumatic suspension by Citroen and Cadillac.

The "Frisky" has a body designed by an Italian and is being built by Henry Meadows Limited, of Wolverhampton.



The power unit for the "Frisky" is an air-cooled Villiers 250 c.c. twin-cylinder two-stroke engine, which has been specially designed for use in light cars. It develops 15 b.h.p. at 5,500 r.p.m.

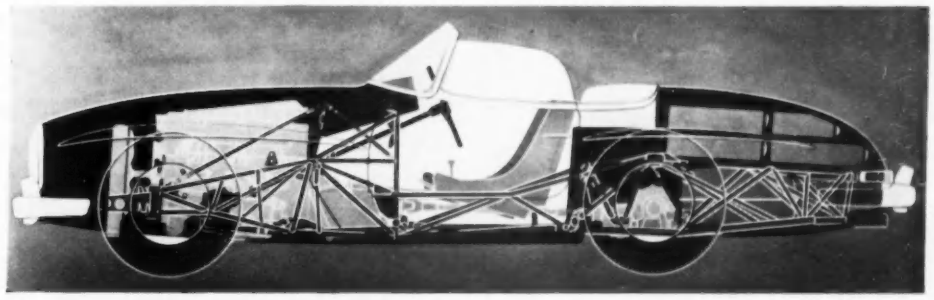
Britain last year sold 5,857 cars in Switzerland out of a total of 56,434, but if we deduct the 3,389 vehicles sold by the Ford and Vauxhall concerns, the rest of the British industry only has a 4 per cent. share in the Swiss market. Germany had the largest share with 30,515 sales, of which 12,632 were accounted for by the American-controlled Ford and Opel factories, together outnumbering Volkswagen. In fact, if sales of American controlled factories in Europe are added to those of American cars, the Americans have captured 37 per cent. of the Swiss market.

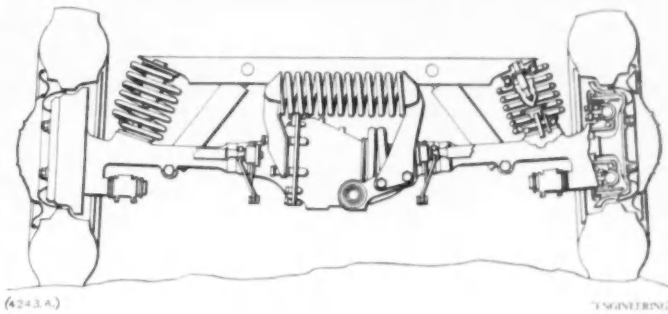
The importance of style was underlined by the widespread publicity given to the Italian-bodied Frisky car to be built by Henry Meadows, Limited, despite some obvious defects in the prototype. At present it is necessary to duck under the lift-up door and clamber over the wheel arch to get in, and the engine projects well into the passenger interior, breaking up the luggage space behind the bench-type seat. It seems that the front wheels should either be further back in relation to the seat to permit a front entrance as on Isetta, Heinkel and Janus, or further forward to give an unencumbered side entrance. However, the idea is an interesting one, conceived by a director of a British motor agency in Egypt, originally to permit local production of vehicles by agents in countries where import permits were hard to get. The tubular chassis can be produced by local labour, and the body is also intended for local production in resin-bonded glass fibre. Imports would thus be restricted to instruments, electrical equipment, and power plant at the most, and licences have already been concluded for manufacture in several countries besides England. In England the power unit will be the fan-cooled parallel twin Villiers two-stroke of 250 c.c., driving through a four-speed gearbox and enclosed chain to a narrow-track rear axle. Reverse is obtained by a Siba Dynastarter, combined generator and starter which reverses the rotation of the engine. There is independent front suspension on the Dubonnet principle and hydraulically-damped coil springs at the rear with rubber bushes as pivot bearings.

The engine has been designed specifically for three and four-wheel cars, and has a turbo-

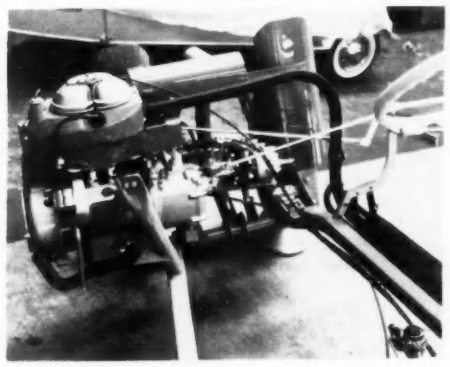
blower cooling system built integral with it. It is a side-by-side twin, with a 50 mm. bore and a 63·5 mm. stroke. The compression ration is 8·2 to 1, and it develops 15 b.h.p. at 5,500 r.p.m. The cylinders are separate castings to simplify foundry production and to improve cooling, and are totally enclosed by the cowling which guides the air from the two fans. One fan is at each end of the engine. Some of the heated air is taken away near the exhaust ports and can be trapped at that point for car interior heating if desired. The four-speed gearbox is also of Villiers design and manufacture. It is of constant-mesh operation with a positive gear change mechanism with internal ratios of 1·0, 1·32, 1·9 and 3·06 to 1. Tests on the road have shown that the engine can provide a speed of 65 m.p.h. maximum, with a cruising speed of between 50 and 55 m.p.h., under which conditions consumption should be at least 65 miles to the gallon. It is stated that the new Villiers silencers eliminate the harshness of the two-stroke exhaust note.

Germany already has a big lead in this "miniature" field with the B.M.W. Isetta (50,000 built in two years), the Heinkel, the Goggomobil (also 50,000 in two years), Maico, Janus, and several others. A remarkable development is the use on the latest Goggomobil of the Getrag Selectromat four-speed gearbox with electric pre-selection. It is a constant-mesh box, with the gears on hollow shafts, inside which run control rods that are moved to and fro by solenoids. Adjacent to a gear of each pair is a group of four holes in the shaft, containing steel balls. To engage the gear, a spool on the control rod is brought into position, forcing the balls out into recesses in an internal bore on the gear, so locking it to the shaft and transmitting the drive. A small lever on the instrument panel selects four forward speed positions and neutral, and a separate button operates another solenoid giving reverse. The gear is engaged by kicking down on the clutch pedal, which makes the contact to the required solenoid while releasing the clutch. The latter runs in an oil bath. In a short road trial the box behaved admirably and gave very rapid shock-free changes. DKW are also offering easier driving in the form of the Saxomat automatic clutch by Fichtel and Sachs on their three-cylinder two-stroke cars. It is a centrifugal clutch engaged and disengaged by a vacuum piston under control of a solenoid-operated air valve on the engine manifold.





The most interesting development in springing at the Geneva Show was the new rear suspension on the Mercedes-Benz 300SL roadster (right). As can be seen above, the chassis is of tubular construction.



From Germany, in the light car field, comes the B.M.W. Isetta. The chain case of the power unit is attached to the rear axle and swings free on quarter-elliptical springs. The drive is through a short shaft with rubber universal joints.

The most interesting new development in springing at the show was the new rear suspension on the Mercedes-Benz 300SL roadster. This is basically the swing axle design with single low pivot, and differential casing swinging with one of the half axles, which is used on other models, but a transverse coil compensator spring is now interposed between the two swing axles, and the rate of the main coil springs has been reduced. Should both wheels simultaneously strike a ridge in the road, the compensator will present the maximum resistance to the type of movement which, in early swing axle designs, could bring the tail of the car down unpleasantly near the road. Should only one wheel strike a bump, the resistance is only half as great, and if one wheel strikes a bump while the other hits a hollow, the compensator presents no resistance to suspension movement. The compensator also intervenes during cornering, and is reported to effect a remarkable improvement in traction and road-holding on loosely surfaced roads. It is believed that the strength of the anti-roll bar at the front has been increased at the same time, and the new scheme represents one more step in a long development process, partly theoretical and partly practical, which has already yielded remarkable results.

Inspection of the Goliath 1100, already described in ENGINEERING (page 318 *ante*), raises the thought that the passengers often fail to obtain the theoretical advantages of a flat floor, unencumbered by a central tunnel, which is possible with front wheel drive or a rear engine. On the Goliath a central tube is used as a major structural member, taking up just as much space as a propeller shaft tunnel. Similar obstructions are found on the Lloyd, Maico, Fiat 600 and Tatra, although none of these cars has a propeller shaft.

Lancia provides an example of the difficulties which accompany efforts to break away from established practice in the production version of the V6-engined Flaminia saloon. As projected by Pinin Farina, this had a four-door body without centre pillars, and no frames to the glass, so that vision along the sides was unobstructed. In the first production prototype, frames were added to the top halves of the doors. Now, to obtain the necessary rigidity in a car intended for comfortable 100 m.p.h. travel, centre pillars have been introduced and the doors are all hinged on their forward edges. The Americans do, however, manage to build large quantities of "four-door hardtops" with no centre pillar obstruction above the waistline. They use massive half-pillars which stop short at the waistline, and the popularity of this type of body, which has no counterpart elsewhere, must be a powerful factor delaying the often

Of particular interest to the Swiss was the Riemerschmid track, which enables a normal Jeep to be converted for rapid travel over deep powdered snow. It has also been demonstrated as transport for use in swamps.

Original conception for a rear-engined sports coupé. Michelotti's design built by Vignale on an Abarth Fiat 750 chassis. Driving vision is rather restricted as the windscreen is too far away from the driver.

Recently introduced is the forward-control Willys Jeep. The chassis is virtually the same as a standard model, with modified steering and driving position.

discussed introduction of unit body-chassis construction in American production. Inspection of the 1957 American cars on view at Geneva reveals what sacrifices in passenger convenience are being demanded to secure the wrap-round windscreens, and the low roof lines, often lower than those on small European cars. In some cases it is a real effort to twist oneself past the cranked screen pillar to get into the driving seat, and the door opening is so low that it is necessary to duck the head sharply when getting out. Moreover, rear leg room is not very liberal in view of the low seats, which demand a more stretched-out position for the legs. A new approach to the whole question of door openings is clearly needed and is undoubtedly being actively developed.

An interesting special-purpose conversion seen for the first time is the Riemerschmid track which permits a normal Jeep to travel rapidly over deep powdered snow. The vehicle, with wheels removed, is clamped to two steel skis, over which runs a light crawler track to provide the propulsion. On snow, the main weight is borne by the skis themselves. The complete crawler unit weighs 2,000 lb., and the specific load of the complete vehicle unladen on the snow is 0·065 kg. per sq. cm. Enclosed primary chains powered from the rear hubs drive the tracks, and levers attached to the front hubs actuate drum brakes on the tracks, so that the vehicle can be turned in its own length by its own steering gear. The track chains carrying the cross-bars also carry steel runners, which run over smaller free chains alongside, and the track bars carry rubber cleats to permit limited road running. The vehicle has also been demonstrated successfully as transport for use in swamps.

Letters to the Editor

GALLING OF TITANIUM

SIR, We were interested to read the article on page 298 of your issue of March 8: "Now Titanium is Cheaper: Its Properties and Uses."

We notice at the end of a statement made by Mr. R. L. Preece, technical service department, Imperial Chemical Industries Limited, Metals Division, that the problem of galling of titanium may be overcome by chemical deposition. We should like to point out that we have perfected the chemical deposition of nickel on titanium, and, on samples, have increased its resistance to galling by more than 50 times. Experiments have been carried out on both rubbing buttons and hydraulic rams. It is now hoped that production work will soon commence.

Yours faithfully,
H. C. HARDWICK,
Assistant to the Manager.

Kanigen Division,
Albright and Wilson, Limited,
49 Park-lane,
London, W.1.
March 21, 1957.

★ ★ ★

TEMPERATURES IN BRAKE DRUMS

SIR, We have read Professor F. K. Bannister's article on "Transient Temperatures in Racing-Car Brake Drums" (ENGINEERING, March 8, page 304) with great interest, as we, at Steel, Peech and Tozer, are also very interested in the heating effects of braking. We are primarily concerned with railway wheels, which are usually stopped by brake blocks bearing on the tread of the wheel, rather than by brake linings bearing on a drum attached to the wheel, as in cars. We feel, however, that our experience of braking under severe conditions justifies us in referring to Professor Bannister's analysis.

There are two points, in particular, on which we would welcome further comment. The first is that it seems that the analysis assumes that there is continuous heat flow into any particular point on the brake drum during braking. Does this not hold only when that point in the brake drum is in contact with the linings? As soon as this point passes away from the lining the heat input drops to zero until the next lining is reached. We feel that cooling by conduction during the periods of zero heat input should affect the analysis.

The second point is that the analysis also assumes complete contact between linings and drum. In railway wheel braking, at least, this is never the case and, with cast-iron brake shoes, the actual area of contact may, on occasions, be as low as 10 per cent. of the shoe area. Fabric shoes are rather better than cast-iron ones in this respect, but, even with these shoes, the actual area of contact never reaches the full block size. The result of this and of any inequalities on the braking surface (drum or wheel tread) is that the heat is not absorbed uniformly; but heat spots are formed which reach appreciably higher temperatures than the rest of the braking surface and interface temperatures well in excess of the theoretical figures are easily obtained. A rough calculation of the temperature rise anticipated on railway wheel treads when braked under our standard testing conditions has been made using the analysis for a semi-infinite slab given in the article. This calculation gave a figure of around 1,000 to 1,100 deg. F. During testing, however, bright red streaks can be seen on the tread, suggesting that spots on the tread reach temperatures of at least 1,800 to 2,000 deg. F. This has been confirmed by microscopic examination of sections through the tread. Parker and Marshall, using a lead sulphide cell to record the instantaneous temperatures reached in braking, have suggested that spot temperatures as high as 2,700 deg. F. may not be uncommon during severe braking.*

We would also like to suggest that the transverse hair-line cracks often found on the inner surface of racing-car brake drums are probably not compressive cracks, but are thermal cracks arising from tensile residual stresses induced into the brake drum by the heat of braking. Similar cracks can be produced in railway wheels by extremely severe braking and we have found that these only appear after cooling the wheel—never during braking. Cast-iron railway wheels are more susceptible to this type of cracking than steel wheels and it is possible that these hair-line cracks may not occur if the racing-car brake drums were made of steel rather than cast iron.

Yours faithfully,
B. BRIAN HUNDY.

Steel, Peech and Tozer,
P.O. Box 90,
The Ickles,
Sheffield, 1.
March 21, 1957.

* R. C. Parker and P. R. Marshall, "The Treatment of Temperatures of Sliding Surfaces with Particular Reference to Railway Brakes." *Proc. I.Mech.E.*, vol. 158, page 209 (1948).

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AN ENGINEER'S CARD INDEX

SIR, With interest, but also to my surprise, I read Mr. R. Silvester's letter, printed on page 38 of your issue of January 11. In my opinion, Mr. Silvester reverses the matter when writing: "Because of the overpowering output of technical literature to-day, librarians cannot be expected to carry out detailed indexing unless the field concerned is very narrow and the librarian has been specially trained in it." From this, Mr. Silvester draws the conclusion that then the engineer has to charge himself with the compilation of a card index of his own. To that view, however, it may be opposed that most engineers do not take pleasure in studying technical literature, have no time for it, and do not possess any knowledge of library and documentation activities.

The engineer is the suitable person, of course, to consult the literature since he knows what data he needs for the solution of his problems. Moreover, a librarian has to see to it that his collection of books remains complete and up-to-date, and he has to control this collection in an exemplary manner. Consequently, the librarian will not be able to find each set of facts for the engineer in a book or magazine. Therefore, to find these data, the engineer has to consult the specialist in this field, namely, the information officer or documentalist.

An information officer ought not only to have a good knowledge of the profession of an engineer, but he should also take pleasure in studying technical literature, have time for it and possess a knowledge of librarianship and documentation activities. The information officer may have a documentation service of his own or he may be employed by a documentation service.

An engineer who wants to go in for research in literature is much too expensive, and in order to ensure an efficient working method he has to co-operate with an information officer. In each separate case, it will then depend upon his own nature in what way he obtains the data regarding literature from the information officer: whether by means of a card index system (which will be compiled in a professional way by the information officer), by means of a list of the literature, or by means of a report on it. In such cases, the engineer himself will have more time for the task with which he has, in point of fact, been charged.

Yours faithfully,
ECO MOULIJN,
Technical Adviser.

Netherlands Postal and Telecommunications Services,
Library and Documentation,
12 Kortenaerkade,
The Hague,
Holland.
March 21, 1957.

Editor's Note: Previous letters on this topic, in addition to that mentioned above, have appeared in our issues of January 25, page 101; February 8, page 165; and March 15, page 326.

Letters to the Editor (continued)

FIRE AT JAGUAR WORKS

SIR, I was interested to read the letter in your issue dated March 15 from Mr. Caryl Thain, managing director of Robertson Thain, Limited, regarding the recent Jaguar factory fire, in which he commented on Mr. Gordon Wilkins' article "Jaguar's Back in Production" (ENGINEERING, February 22, page 323).

While agreeing with much of what Mr. Thain says about roof structures generally, I would suggest that his conclusions regarding the Jaguar fire are incorrect, in so far as they lay emphasis on the lining of the roof with fibre insulating board rather than on the inflammable nature of the bituminous roofing itself.

I myself accompanied the chairman of my technical committee on a visit to the Jaguar factory within a few days of the fire and, through the good offices of all concerned, including the management of the factory and the chief officers of the Coventry Fire Service, was able to obtain first hand information regarding the probable sequence of events. It was abundantly clear that the prime factor contributing to the rapid spread of the fire was the high bitumen content in the roof covering and flashings. It was apparent that this had melted and run ahead of the progress of the fire and naturally involved the fibreboard lining as well as scattering over the whole factory area.

This view is confirmed by the technical information sheet issued by the Fire Protection Association in connection with the Jaguar fire. The title of this sheet is "Spread of Fire by Bituminous Roof Coverings," and in it the Fire Officers' Committee quote the parallel example of the largest recorded industrial fire which has ever taken place, the fire at the General Motors factory at Michigan, where the bituminous roofing became ignited, melted, and the fire spread over practically the entire plant. In that case there was no fibre insulating board lining, a fact which speaks for itself.

Fibre insulating board is one of the most widely used and efficient insulating materials for the lining of buildings, but like any other material it should be used properly. When applied in existing buildings, it naturally has to be added underneath the roof structure and it is advisable to break up air spaces by fire stops and similarly not to leave open ends. Where the fire risk is high, as when fibre insulating board is used to line a roof with a high bitumen content, treatments are readily available which give a Class 1 spread of flame rating to fibre insulating board.

The necessity for proper structural precautions against fire, including fire breaks in large factory spaces, and for care in the storage and handling of inflammable contents of buildings, is applicable whenever materials are incorporated in linings or roof construction.

Yours faithfully,
L. R. CHAMBERS,
Director-General.

Fibre Building Board Development
Organisation Ltd.,
47 Princes-gate,
Westminster,
London, S.W.1.
March 25, 1957.

★ ★ ★

COURSE ON INDUSTRIAL LAW

A course on industrial and factory law will be held under the auspices of the Industrial Welfare Society on May 28 to 30 at Robert Hyde House, 48 Bryanston-square, London, W.1. Mr. Harry Samuels, M.A., Barrister-at-Law, will be the lecturer. The course covers the legal groundwork necessary to industrial managers and executives. Particulars of the course can be obtained from the secretary of the Society at the above address.

Weekly Survey

Cover Picture: *Be it a cogging or a blooming mill, or a high-speed mill for the production of cold-rolled sheet or strip, the modern rolling mill is a high precision plant, built with the care given to a machine tool which, in fact, it has become. The illustration this week shows the assembling of the bottom distance piece of the roll housings of a* 42 *in. blooming rolling mill.*

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Steel in Two Countries

The annual report of the United States Steel Corporation published last week contains facts and opinions that would fit well into any British company report. Sales in 1956 were the highest ever, but "a five-week strike caused profits to fall below the 1955 level." Inflation is roundly denounced and the danger pointed out that it may become "a permanent feature of American life," owing to "the vast power of industry-wide labour unions in compelling annual increases in employment costs far beyond increases in productivity." The problem of financing the business is becoming increasingly difficult, and the fact is underlined that "income tax law limits the total depreciation recoverable during the life of a facility to the number of dollars originally spent for it years ago."

Two reports were published recently by British steel companies: the Hadfield group, for the year ended September 29, and the United Steel Companies, Limited, reviewing progress during 1956. Lord Dudley Gordon, chairman of Hadfield, had this to say on financing the business: ". . . this heavy capital expenditure cannot be met in full by the internal resources of the company, which cannot be adequately increased while profit margins remain low and crushing taxation has to be met." The cost of research is all the heavier for the new requirements of nuclear engineering, for which the company have developed a number of new alloys. "The most important of these are the boron steels which have unique neutron absorbing properties."

The United Steel Companies' brochure, entitled "A Report for Employees," is an excellently presented statement of the company's activities in the wider contest of British steel production. The steel industry as a whole, it says, has been spending about £1 million a week on new plant and equipment and will have to spend even faster to meet the new target of 28 million ingot tons in 1962. U.S.C. have been keeping up with the rest of the industry: "we still make about 1 ton in 8 made in this country." A diagram shows that expansion in the United States is no greater than in Britain: "there are only two countries in the world which are going faster—Russia and Germany. Russia has doubled her output in the last seven years and plans to continue at this rate." Germany is now the third largest producer, Britain fourth. There lies the main threat to this country's industrial future.

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Tin Prices

The meeting last week of the International Tin Council focused attention on the trend of tin prices, since the Council was due to reconsider a request from Bolivia for a substantial increase in the range of prices written into the tin agreement. The original agreement was concluded in 1953 when it was feared that tin prices would collapse if the United States ceased buying. It was expected at that time that world production of tin would exceed consumption by over 40,000 tons a year, or nearly one-third of the level of world consumption at that time. In order to provide a measure of stability it was laid down that the manager of the buffer stock must buy tin when the London Metal Exchange price fell to £640 a ton and must sell tin when the price rose over £880 a ton. When the price was between £640 and £720 a ton he was empowered to buy tin at his discretion, and between £800 and £880 to sell. With a price between £720 and £800 he might neither buy nor sell unless empowered to do so by the Council.

In practice, for the greater part of 1956 and the early part of 1957, the price has been between £720 and £800 apart from two periods, in February and November, 1956, when it touched the upper limit of £880. Even if the price had exceeded that level no action could have been taken because the buffer stock held no metal, producers having discharged their initial obligation by contributing cash rather than tin. The effect of the Council's decision has been to raise the lower limit of £640 a ton to £730 the permissive buying range now being £730 to £780, and the permissive selling range £830 to £880.

World consumption of tin has been rising in recent years and has been at a higher level than was anticipated in 1953, with the result that the excess of production in 1956 has been estimated at only about 10,000 tons. Nevertheless, tin is the only major industrial raw material of which consumption is lower than in some pre-war years, and a good deal of substitution has taken place either on grounds of price or for technical reasons. It is therefore doubtful whether an increase in price can be justified in the long-term interests of producers. On the other hand, there is justification for raising this floor price which will permit the buffer stock to acquire tin since, in the event of a sudden price rise due to increased consumption or dislocation of production, there is at present no means of implementing the provisions of the agreement, which were designed to provide a ceiling price.

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Over-production of Tungsten

The Board of Trade announced last week that its trading stocks of tungsten ores had been virtually disposed of during the last few years but that 500 tons are available from its strategic stocks. The Board's selling agents, British Tungsten, have been given instructions to dispose of this quantity gradually so as to avoid undue disturbance of the market. Prices of tungsten have in fact been weak for a considerable time and in the last half of 1956 fell by about 40*s*. to 220*s*. a unit. In the current year, prices have fallen even more sharply and at the beginning of March stood at 160*s*. to 170*s*. a unit. There have been a number of reasons for this quite apart from the depressing effect of the liquidation of Board of Trade stocks.

World production of tungsten ores approximately doubled between 1949 and 1952, but from then until 1956 there was little change in output. The main reason for the rapid increase in production was the high price paid by the United States Government in order to build up their strategic stockpile, but in the second half of 1956 a number of contracts for delivery to the stockpile expired. Although some high cost mines which could only operate at premium prices closed down, others, such as those in Bolivia, began to sell on the open market. Further contracts with the American Government are due to expire during 1957. In addition, some Communist countries have been selling ferro-tungsten to Western Europe. Some more small mines are expected to cease production during the year but it will probably be some time before a state of equilibrium between supply and demand is reached.

In the United States it will probably take even longer to achieve such equilibrium. In 1955 domestic production was estimated at 16 million lb. (WO_3 content of ores), imports at 22 million lb. and consumption at only 8 million lb. It has been calculated that the United States

Government stockpile probably amounts to about 20 years supply at current rates of consumption or 8 years supply at the highest rate ever reached, namely during the war in 1943. Moreover, although the United States Government has announced its intention of reducing domestic production by half over the next two years, the actual prices fixed are such that little effect is expected. It seems unlikely, however, that Congress will be willing to continue very much longer paying more than twice the world price in order to keep high cost mines in production. The industry has therefore instituted a research programme to find new uses for tungsten with particular emphasis on the development of high-temperature tungsten base alloys for jet engine parts. The high prices prevailing for tungsten have already resulted in large scale replacement by molybdenum in tool steels and there is little doubt that the long term health of the industry in the United States requires a substantial fall in price similar to that which has already occurred elsewhere.

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Advertising Abroad

The engineering and metal industries account for some 46 per cent. of all British exports. It is fitting, therefore, that an eminent engineer, Sir Edward D. A. Herbert, should deliver the first address to the Export Advertising Conference held in London last week under the auspices of the Advertising Association. After a long and distinguished career in heavy engineering, much of it overseas, Sir Edward is now managing director of a leading firm of shirt manufacturers, William Hollins and Company. He spoke on the United States market, where he found trading both exciting and rewarding and a unique testing ground for a manufacturers' product policy and marketing skills. "Courage," he said, "is essential to success. Courage in spending money and energy and time in promoting the sales of your products, once you are convinced that the goods are of a kind for which a market can be created." The experience of William Hollins in the United States, the manner in which they tackled it—"we spent the best part of two years in surveying the market from coast to coast—" and now the rewards they are reaping make both educative and stimulating reading.

An engineering company, Dexion Limited, described their experience in establishing export sales for half their production. The manager of their overseas division, Mr. Geoffrey Young, stressed the need to give status and financial independence to the export sales department—it is only too easy, he said, to allow it to develop "on the lines of a poor sister of the all important home sales organisation." Companies, he said, must organise themselves so that they get a constant stream of information about each market, on the performance of competitors, the users' reactions to their products, price levels, the impact of sales promotion, the new ideas that are being tried and all the facts and figures necessary for effective advertising and intelligent marketing.

Contributions from the advertising agencies suggested that a great deal is being done for the exporter but that, so far, only very few can provide adequate services for successful advertising abroad. The remark of one of them, that it is "lack of demand rather than lack of interest" which is the main reason for this inadequacy, is probably near the mark. This conference has provided a useful stimulus to fresh thinking on the subject.

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Heavy Engineering Expansion

No sign that demand for heavy engineering products is on the wane can be found in the annual reports published last week. The Power-Gas Corporation Limited—gas, chemical and steel plant engineers—announce a major expansion programme to be completed in 1958 at the cost of about £1 million, which is to be met by a recent capital issue. The fact that requests for excess shares greatly exceeded the available supply shows that investors endorse the company's optimism. Their vice-chairman, Major W. R. Brown, said they were making special efforts to expand overseas trade and would face the increasing challenge of overseas competition with confidence. Foster, Yates and Thom Limited, heavy precision engineers and boilermakers, were even more specific, though in their case the shortage of steel is a major handicap. The chairman's statement indicated that trade was continuing to expand: "The company's work in progress now stands at the highest in its history, and the order position continues to be most satisfactory. The country seems always to demand more goods than the available material can satisfy . . ."

Steel supplies remain a serious obstacle to growth for nearly all users of heavy plate. The chairman of International Combustion (Holdings) Limited, Mr. G. R. T. Taylor, mentioned in his report a continued increase in output "achieved against a continuing background of material shortages, which, in certain classes of steel, still remains acute." The building of a new light engineering shop at Derby—"to provide additional space needed for heavy unit production and assembly, and particularly for the newer types of constructions with which we expect to have to deal in the future"—will relieve pressure on existing facilities. Capital commitments amount to some £350,000 despite the fact that "orders received for the large central station units receded substantially." The group's profits for the year ended September 30, 1956, were £1·8 million, 14 per cent. greater than the previous year.

The reports of two other companies, Crosthwaite Furnaces and Scriven Machine Tools Limited, who make furnace equipment as well as heavy presses, and Mather and Platt Limited, showed the same expansionist tendencies. Mr. H. A. Perkiss, chairman of Crosthwaites, reported full capacity working, record sales and that a full order book ensured good prospects for the current year. Shortages, in this case of skilled workers, were the main limiting factor. Mather and Platt are committed to spend nearly £½ million on new plant and expansions. Mr. L. E. Mather, chairman, said that overseas business had shown "gratifying results." There lies the key to a further major expansion of British heavy engineering.

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Export Rise Continued

A welcome return towards normality is reflected in the overseas trade returns for February, 1957, published last week. In December and January, United Kingdom exports were suffering from delays imposed through rerouting via the Cape. In January particularly, considerable quantities of goods for export were held up at the dockside while available ships were pursuing a wide diversion to avoid the Suez Canal. By February the situation became easier as these ships returned, and exports rose to £278·2 million, an increase of 6·5 per cent. over the previous month. The increasing availability of shipping also meant that imports in February were unusually high at £320·8 million. February imports are usually low and this figure compares with an average import value of £325 per month during the last two years. Current expectations that normal working will shortly be resumed through Suez are dependent to a large extent on the political situation, but there is every chance that the normal pattern of trade should return by early summer, if not sooner.

In the unusual circumstances of the past few months it is difficult to make any useful comparison with 1956. To allow for this, the Board of Trade have taken as a basis the four months ending February, 1957, and February, 1956, respectively. During the period November, 1956, to February, 1957, United Kingdom exports were running at a monthly average of £271 million. This was 6·5 per cent. higher than the corresponding period in the previous year. While this increase is smaller than the 10 per cent. rise in 1956 compared with 1955, it is possible that the figures for the next few months will reveal a compensating increase as additional delayed cargoes are dispatched. In any case, it is apparent that fears of serious dislocation of export trade as a result of developments at Suez have been to a large extent unfounded. A much more potent factor affecting exports may well be the industrial unrest which is at present pervading British industry. Unless this is quickly brought under control, the advantages of increased availability of shipping will be more than cancelled out. At the moment the engineering industry, which accounted for 46 per cent. by value of total British exports in 1956, is holding its own in the export field; it will be a pity if this good record is spoilt.

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Ups and Downs in Overseas Trade

One of the most disquieting features of last year's trade returns is that the United Kingdom share of world trade in manufactured goods grew less. In the first three quarters of 1956 the United Kingdom share fell to 19·3 per cent. from 20 per cent. in 1955. That of West Germany, on the other hand, increased from 15·2 per cent. to 16·1 per cent. The United States' share went up from 24·8 per cent. to 25·4 per cent. The most successful British industries were non-electrical machinery, aircraft and ship and boat building. These three between them accounted for 43 per cent. of the year's increase in exports. Aircraft purchases by the United States were valued at £17 million against £3 million in 1955. Australia bought aircraft worth £11 million against only £2 million in the previous year. The increase in shipbuilding was the result of the purchase of several large vessels by Norway and Canada. Among the lesser successes were electrical machinery (plus £25 million), iron and steel (plus £17 million), and railway vehicles (plus £5 million).

The other side of the picture is seen in the fall of £5 million in motor car sales. This was largely due to the reduction in sales to Australia and New Zealand following reimposition of import restrictions. Textiles have met further competition from cheap goods from Japan and East European countries.

So far as trading areas are concerned, the biggest increase was with the dollar area, but Japan took 64·1 per cent. and India 29 per cent. more British goods than in the previous year.

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Deportment of Engineers

In the words of its President, Dean Thorndike Saville, in its annual report for 1956, the Engineers' Council for Professional Development, of the United States, is a somewhat odd sort of organisation. Composed of three representatives of each of eight constituent engineering organisations, it meets only once a year, its activities being carried out by a number of committees covering such subjects as: education and accreditation, student development, training, recognition and ethics, among others. A guidance committee is engaged in an attempt to interest schools in engineering by the dissemination of literature, by sending counsellors to talk to pupils and by the organisation of clubs with the name of JETS (Junior Engineering Training for Schools) of which there are now 86 in 19 states.

One of the main functions of E.C.P.D. is the

accreditation of engineering courses, for which it is now recognised as the main authority. For the current academic year, 808 curricula of university level have been accredited in 153 engineering schools. Of recent years increasing attention has been paid to the training of technicians, and the American Society for Engineering Education has received a grant from the Carnegie Corporation for the purpose of studying technical institute education in the United States. E.C.P.D. has for the last decade been accrediting technical institutes, and 93 programmes of instruction in 32 institutions have been approved. In order to obtain approval, courses must consist of not less than one academic year of full-time work or the equivalent in part-time work, and students must have high school graduation or equivalent.

The Council is much concerned with problems of status and ethics, which are to be examined by the proposed survey of the engineering profession which has already been described (page 194 February 15). The Recognition Committee has been studying the problem of definition and has suggested the following: "Engineering is the profession in which a knowledge of the mathematical and physical sciences gained by study, experience and practice is applied with judgment to develop ways to utilise, economically, the materials and forces of nature for the progressive well-being of mankind." After this it is rather a shock to find the student development committee reporting that "Careless dressing, sloppy handling of pipe or cigarettes, public drinking, swearing, and poor English are all contributors to the public's lack of respect for the engineer." Presumably to demonstrate his "professionalism" the engineer will have to develop a bedside manner !

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France at Odds with Europe

The condition of the French economy cannot fail to cast a gloom over the signing of the European Common Market Treaty. Ever since the Messina Conference of June, 1955, negotiations have been going on, mostly under the indefatigable M. Spaak, to decide the terms on which a Common Market could be set up. First there were the long discussions which produced the Spaak Report of April, 1956. This was quickly endorsed at Venice in May and the drafting of the treaty began. Throughout all these negotiations the French point of view appears to have prevailed—the harmonisation of social service charges, the special treatment of agriculture, the fixing of minimum import prices for agricultural products and, biggest concession of all, the inclusion of the overseas territories. Now the great moment that so many have looked forward to has arrived. The treaty is all ready for signature. Everyone is happy—M. Spaak because he will now be able to tear himself away to take up his new post as Director-General of NATO; Dr. Adenauer because it should now be possible to get the treaty ratified before September's general election. And what is the French reaction ? At this moment of climax, with the Common Market train about to start, France pulls the communication cord and reintroduces protection.

An import tax of 15 per cent. is to be imposed on all "freely importable" goods. These are the commodities on which import restrictions have been removed under the O.E.E.C. trade liberalisation code. Import licences are to be granted only for three months and will be harder to get. The Bank of France is imposing a credit squeeze, and a budget reduction of £250 million is forecast. At the same time the Government is spending wildly on subsidies to keep the cost of living index down to below 149·1, the point where automatic sliding scale increases take place. Is it any wonder that industrial opinion on the Common Market in Britain is uncertain when one of the principal signatories is engaged in demonstrating that she will find it difficult, if not impossible, to meet her treaty obligations ?

A FULL LIFE FOR STUDENTS AT IMPERIAL COLLEGE

The offer of Vickers Limited to provide for the Imperial College of Science and Technology a hall of residence is a far sighted action in line with current thinking on the education of scientists and technologists in this country.

In the United States a great deal of attention has been given in recent years to broadening the education given to engineering students by the inclusion of courses in the arts and social sciences. The need for this arose, first of all, in institutions which were originally of a narrow character, such as the Massachusetts Institute of Technology, when it was discovered that men trained in them were not capable of dealing with the managerial problems of the modern age; as a result, all engineering courses now include compulsory periods in these subjects which are insisted on by the Engineers' Council for Professional Development, the body responsible for accrediting, for degree purposes, schools of engineering in the United States. In fact these courses are now given precedence, at least for undergraduate students, over courses in specifically management subjects.

It has to be borne in mind, however, that nearly all American universities and colleges are residential, whereas outside Oxford and Cambridge the number of residential places in universities in the United Kingdom is very small and, in London, almost negligible.

The view that has been growing up in this country, where the school educational background of those going to universities and, it is hoped, to the colleges of advanced technology, is of a higher level than that of the United States, is that the same object will be better achieved by giving all students at least a period in residence and by encouraging extra-curricula activities.

Although in London the colleges are widely separated and there is little contact between the Imperial College and the rest of the University, it must be a very philistine student who does not feel in any way the result of his exposure to the many cultural activities that go on in the capital. On the other hand, the "little brown baggers" who return each evening to their homes or distant lodgings are hardly likely to contribute much to that interchange of ideas in the small hours of the morning which is such a valuable feature of undergraduate life.

The new hall of residence is to be built in Princes-gardens, London, S.W.7, adjacent to the main buildings of the Imperial College, and the intention is to provide modern and attractive accommodation for about 70 students, of whom up to 15 will be Vickers undergraduate apprentices. An architect's impression of the new hall shows that the premises will consist of two buildings, one appearing to have seven and the other eight storeys. Announcing the scheme in London on March 20, Viscount Knollys, chairman of Vickers Limited, said that it was hoped that the building would be completed by 1959. It is to be named after Lord Weeks, who was chairman of Vickers until his recent retirement.

He added that his firm had promised the College a grant of £150,000 to build and fit out the hall of residence, but that it would be maintained and operated by Imperial College. The hall would be available, on agreed terms, for the Vickers group of companies during vacations as a staff college for courses in management and other forms of education and training.

Another development announced by Lord Knollys on March 20 was the foundation of three new engineering scholarships, each worth £400 a year and tenable for three years, to be known as the "Vickers Scholarships." They would be set up as the responsibility of the Vickers Group at the University of Cambridge. Initially the scholarships would be introduced at yearly intervals; in 1957 at Christ's College, in 1958 at Downing College, and in 1959 at Trinity Hall. These new engineering scholarships at Cambridge brought the total series of named scholarships of various kinds to 20.

The conditions regulating the three new scholarships have been issued by the company. Selections will be based on the General Certificate of Education and a personal interview before a selection board. Each holder of a scholarship will normally be required to enter as an undergraduate apprentice in one of the companies of the Vickers group having an established apprentice training scheme. After serving one year as an apprentice, he will take up residence at Cambridge and then finish his apprenticeship with a further year of training with the company. Further particulars regarding the new scholarships are obtainable on application to Vickers Limited, Vickers House, Broadway, London, S.W.1.

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TRAINING FOR THE NEW DIPLOMA IN TECHNOLOGY

Each year the universities in this country produce about 5,000 pure scientists and 2,500 applied scientists or technologists and, annually also, the technical colleges turn out some 9,000 persons at the level of the Higher National Certificate. Among these 9,000 there are many who, given the opportunity of obtaining a higher award, could do so. Speaking at the annual assembly of the Nottingham and District Technical College on March 15, Sir Harold Roxbee Cox said that in the future such an opportunity would be available. Another means of identifying technologists of high quality had been established. The National Council for Technological Awards, presided over by Lord Hives and of which he (Sir Harold) was vice-chairman, had already instituted the Diploma in Technology. This Diploma would be awarded to persons who successfully completed courses of study recognised by the Council. These would generally be sandwich courses, in which roughly half the time was spent in industry and half in academic studies. In standard they were at the level of an honours degree at a good university.

This new award had met with considerable initial success. Up till the present the Council had received 59 applications for the approval of courses. It had completed the consideration of 37 and had given its recognition in the cases of 28. As it had been possible for some of these approvals to be retrospective there might well be between 40 and 50 candidates for Diplomas in Technology in 1958, nearly a 100 in 1959 and greatly increased numbers in subsequent years.

No college so far visited, Sir Harold pointed out, had yet achieved the standards which the Council regarded as appropriate, but the Council realised that it had to be practical, and if plans were clearly in hand to provide, in the near future, what it believed was necessary, then the courses for which approval was sought were being recognised, provided they met the required academic standards.

Particulars of the 28 courses recognised by the Council and mentioned by Sir Harold in his address have been issued by the Ministry of Education on behalf of Lord Hives and the Council.

The 28 recognised courses are now in progress or have been approved at Battersea Polytechnic, Acton Technical College, Birmingham College of Technology, Cardiff College of Technology and Commerce, Chelsea Polytechnic, and Woolwich Polytechnic. Battersea Polytechnic provides full-time, as well as sandwich, courses in applied chemistry; chemical, mechanical, civil and electrical engineering, and metallurgy and a sandwich course in physics. All the other

technical colleges provide sandwich courses only; those at Acton and Birmingham cover applied chemistry, applied physics and electrical and mechanical engineering and those at Cardiff and Woolwich courses in engineering subjects. A course in applicable mathematics is available at Chelsea Polytechnic.

Lord Hives states that a considerable number of courses are now being considered by the Council, and colleges will be given decisions with all possible speed. He adds that two of the colleges at which courses have been recognised, namely, Acton Technical College and Woolwich Polytechnic, are not colleges of advanced technology and he hopes, therefore, that this will be a source of encouragement to all technical colleges.

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HIGH SALARIES FOR ARTS GRADUATES

Startling evidence that a degree in science or in technology is not the best passport to the better paid jobs in management is given in the latest broadsheet published by P.E.P. entitled *Salaries of Graduates in Industry*. This is based on interviews with some 600 graduates and relates to men who had been in employment for four years in the autumn of 1954. Much of the information given in the broadsheet was obtained from the material on which P.E.P.'s report *Graduate Employment—A Sample Survey*, 1956, was based. In addition some information is given on starting salaries at which graduates were recruited in industry and elsewhere in 1956.

P.E.P. found that at the starting salary stage, arts graduates recruited into industry were being paid some £70 a year less than scientists but some £10 more than technologists (men with a degree in engineering). Four years later, however, arts graduates were ahead of the scientists by about £30 and slightly ahead of the technologists in industry. The arts men in industry were in fact earning, on an average, more than any arts graduates in any other walk of life. In their review of present-day starting salaries P.E.P. give the range for arts graduates at between £500 and £760, "with most offers running between £550 and £650." Starting salaries for scientists and technologists are now approximately equal, suggesting that the market has become more favourable to technologists than it was in 1951. They range from £550 to £775 "with most above the £600 mark."

The authors make some reservations about the size of the sample, but none the less conclude that "a salary policy that offers little advantage to scientists and no advantage to technologists over arts men at the outset of their careers, and then promotes some of the arts men to positions carrying higher salaries than those filled by any of the scientists and technologists, is not well calculated to encourage men to read science and technology rather than history or languages or some other non-technical subject." These charges have been made before and are likely to be entirely justified. But it is not, as P.E.P. imply, the product of a co-ordinated "salary policy" on the part of industry. Such a policy does not yet exist, except among a handful of large firms.

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ANOTHER WAY IN WHICH FIRMS CAN HELP THE COLLEGES

What appears to be an innovation in teaching method has been made at Birmingham University with the transfer of a regular end-of-term students' conference from the University to the premises of a large industrial concern. Traditionally, at the end of the Easter term, undergraduates, graduates and staff of the University department of metallurgy combine to take part in a conference featuring some aspect of their work. This year the subject was "Industrial Organisation and Administration" and at the suggestion of Professor E. C. Rollason, head of the department, the conference was held at the headquarters of the Metals Division of the Imperial Chemical Industries Limited. The students were also conducted over the works.

Although the conference and works visit were compressed into only one day, the impact of lectures given by senior men in industry elsewhere than in familiar lecture rooms was found to crystallise many ideas which the students had previously met only in formal lectures in their classrooms. It was also found possible to convey something of industry's approach and to show how different aspects of a problem—research, design and planning of a full-scale plant, and production—were handled in a large fully integrated company.

Of the success of this year's conference there is no doubt and it is to be hoped that other large companies, in all branches of engineering, will see their way to offer similar opportunities to colleges. Works visits by themselves have long been popular with students and many firms have increased the instructional value of such visits by arranging for a senior member of the staff to give an explanatory talk on what the students have seen. Nevertheless, the giving of a short series of lectures, planned in conjunction with the college to amplify some particular aspect of the students' course, is an improvement having advantages for both the students and the firm which are well worth repeating.

AIRLINER ACCIDENTS

On November 5 last year, a Hermes aircraft G-ALDJ on a charter flight from Tripoli with 74 passengers—nearly all service men's families being evacuated at the time of the Suez crisis—crashed at Blackbushe airport while attempting a night landing. The aircraft undershot the runway, hit a tree 3,617 ft. short of the threshold, and finally came down among some pine trees. It then caught fire. Of the six crew members and 74 passengers on board, the captain, first officer and radio officer were killed by impact, and four children—put out through an emergency exit on to a wing—were burned to death. The report of the public inquiry on the accident was published last week.

Although the Commissioner of the Inquiry found no evidence of technical failure in the aircraft or in the instrument landing system on which the pilot almost certainly based his approach, there are one or two points of technical interest arising from the report. The Commissioner was unable to reach a positive conclusion on the cause of the accident. He thought it most likely arose from the pilot being abnormally fatigued and misjudging his height through relying on his vision of the airport lights and failing to check on his altimeter or ILS indicator.

The approach lighting system at Blackbushe airport was installed some years ago and is below the standard now called for by the International Civil Aviation Organisation. The court Commissioner suggested that, had the lighting system been more in accordance with the latest ICAO recommendations, the pilot might have had a better visual indication of his height. ICAO have already been urging contracting states to bring their approach lighting systems up to date.

A second point which emerged is that the system for estimating the runway visual range (RVR) at Blackbushe airport was subsequently found to be inaccurate and the pilot had, in fact, been informed that the RVR was 1,200 yards when in fact it was only 930 yards. Although in this case the inaccuracy would probably not have affected the pilot's decision to land, since a minimum visibility of 800 yards is considered acceptable for landing a Hermes aircraft, such errors are clearly undesirable, and the Ministry of Transport and Civil Aviation have already taken action to ensure that the system of estimating RVR is periodically checked.

The third point worthy of note is that not one of the passengers, who were accommodated in backward facing seats, was killed by impact, and that 73 of the 80 people on board escaped.

The report on the Hermes accident was published at a time when public interest was focused on another airliner accident—the Viscount 701 G-ALWE at Ringway airport, in which all aboard were killed as well as a woman and child in one of the houses that were demolished in the crash. Following the discovery that one of the bolts attaching the guide rails of the double-slotted flaps on G-ALWE had fractured, all B.E.A.'s 701-series Viscounts were withdrawn from service for inspection and replacement of the bolts. By last weekend, they were all back in service, from which it may be deduced that B.E.A. are satisfied that the immediate cause of the accident is known. No official statement has yet been made since the public inquiry has still to be held, and it is possible that more information may come to light on the reasons why the bolt fractured. An explanation of the mechanics of the accident that has been advanced is that, as a result of the bolt fracture, two sections of the three-section flap folded upwards causing the aileron control rod to jam. Further modification action is likely when the full facts have been determined.

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WHITWORTH FELLOWS

The beginning of a new stage in the history of the Whitworth Foundation was emphasised on March 18 when at the annual dinner of the Whitworth Society the main toast took the form of "The New Whitworth Fellows." The occasion was the 32nd Commemoration Meeting of the Society and the date the 89th anniversary of the day on which Sir Joseph Whitworth took the first steps in the inauguration of his scholarship scheme.

The changes which have taken place over the years were indicated by Mr. A. L. Bird, the proposer of the toast, and Mr. F. M. Burrows, the new Whitworth Fellow who replied. Mr. Bird, who is well known to many Cambridge men as Hopkinson Lecturer in Applied Thermodynamics at the University until his retirement in 1950, pointed out that when he gained a Whitworth Exhibition in 1905, "heavier-than-air flight had only then been achieved." In contrast, Mr. Burrows announced that he had been engaged in research in connection with a Lancaster bomber in what he referred to as a "flying wind tunnel." This was at the College of Aeronautics. The changing pattern of engineering education may be illustrated from the cases of these two speakers. When Mr. Bird obtained his Exhibition it was necessary that he should have served an apprenticeship. This condition did not apply to Mr. Burrows' Fellowship, although later workshop training was required. Actually he had already complied with this condition. Formerly a choir boy at St. John's College Chapel at Cambridge, he spent two years obtaining a general education at a technical college, then serving an apprenticeship and obtaining a Higher National Certificate by part-time study and passing to Cranfield. Cambridge men will have no difficulty in understanding that Mr. Burrows is "particularly gratified" by the fact that he can now return to St. John's College.

The chair at the dinner was occupied by the President, Mr. P. L. Jones, M.C., who replied to the toast to the Society proposed by Mr. G. W. Daniels. It was announced that Mr. I. V. Robinson had resigned from the position of honorary treasurer and that Dr. F. T. Barwell had been appointed to the post, retiring from the position of honorary secretary which he has held for many years. Dr. R. G. Woolacott is the new secretary.

CHEMICAL AND INDUSTRIAL GLASSWARE

The main product of Quickfit and Quartz, Limited, a concern formed at King's Norton, Birmingham, in 1934, as one of the Triplex Group of Companies, comprises laboratory glassware having standard interchangeable conical ground-glass joints. In the production of these, the cones and socket blanks are preformed on lengths of tubing and on flasks and other apparatus, and are then inspected and annealed. Grinding produces the final accurate taper which ensures gas and liquid-tight seals. These standard interchangeable joints greatly facilitate the assembly of chemical apparatus and are used on an extensive scale in atomic-energy research establishments, in university and hospital laboratories and in the chemical analysis and research departments of a wide range of industries as varied as the iron and steel trade, food-preparation processes, and the manufacture of nylon yarn. An operator is seen producing a socket blank on a length of tubing in Fig. 1. Fig. 2 shows the inspection of finished apparatus.

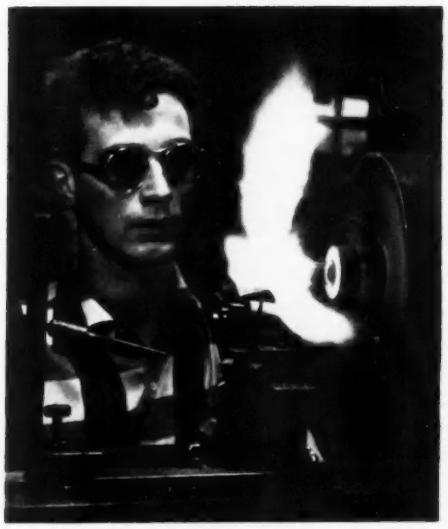

Fig. 1 Making a socket blank on the end of a glass tube to be employed in the production of a standard interchangeable conical ground-glass joint. These joints greatly facilitate the assembly of chemical apparatus and are used on an extensive scale in industrial and research laboratories.

Fig. 2 Inspection of finished chemical glassware. Some typical standard interchangeable conical ground-glass joints are seen in the rack in the foreground.

Quickfit and Quartz, Limited, moved their main works to their present address, Heart of Stone, Stone, Staffordshire, in August, 1946, and, since that date, extensions have been built and other buildings in the vicinity of the factory acquired. These enlarged premises have been necessitated not only by the increased production of the firm's interchangeable laboratory glassware, but also on account of the steadily augmenting volume of production of industrial plant in glass, a relatively new activity of the firm, which is rapidly growing in importance. In order to deal with this increasing production, a development and marketing company for industrial plant, styled Q.V.F. Limited, a contraction of the name " Quickfit Visible Flow," was formed in 1953 jointly by Quickfit and Quartz, Limited, and James A. Jobling and Company, Limited. The works address of the new company is Mill-street, Stone, Staffordshire. The realisation of the great potentialities for glass chemical plant and glass pipeline in widening fields of industry at home and abroad was one of the main incentives in the formation of Q.V.F. Limited.

The production of chemical plant depends upon three fundamental types of glassware, namely (*a*) tubing for pipeline; (*b*) blown mouldings for such apparatus as storage vessels, reaction apparatus and stills, and fractionating columns; and (*c*) glass pressings accurately produced in quantity to standard shapes. A glass pipeline may be a combination of machine-drawn tubing and glass pressings and a glass heat exchanger, a combination of machine-drawn tubing, blown mouldings and glass pressings. Glass pipelines, the largest of which so far produced by Q.V.F. Limited measures 18 in. in diameter, are employed in chemical manufacture for conveying corrosive fluids and strong acids, and in food manufacture for the carriage of fruit juices, pulps, sauces, vinegar, milk and alcoholic and other beverages.

Glass condensers are used for the distillation and recovery of corrosive chemicals, acids, drugs, and alcohols. Glass boilers or heat exchangers are employed for the preheating of corrosive liquors prior to feeding them to stills or vats, and for such purposes as the concentration of fruit juices. Glass batch stills having vessels of 10, 20 and 50 gallons capacity are available with a range of fractionating columns, stillheads and condensers. Glass extractors and scrubbing towers are produced for liquid-liquid or liquid-solid extraction, for gas-liquid scrubbing, and for gas absorption.

Owing to its many advantages, including the elimination of corrosion; maintenance of purity and cleanliness; transparency enabling plant control to be effected visually; an appreciable saving in weight; and a low coefficient of linear expansion, industrial plant in glass has become standard equipment for a variety of purposes in the brewing, dairy, mineral-water and essential-oils industries, and for the production of a number of fine and heavy chemicals and pharmaceuticals, textiles, petroleum derivatives, and other substances.

DEVELOPMENTS IN PAINT MATERIALS

The main purpose of a technical exhibition organised by the London Section of the Oil and Colour Chemists' Association, Memorial Hall, Farringdon-street, London, E.C.4, and staged in the New Hall of the Royal Horticultural Society, Westminster, recently, was to display recent advances made in the materials, equipment and technology provided by member firms of the Association, and employed in the manufacture of paints, printing inks, varnishes, lacquers and other materials. The exhibition was the ninth of the series and was opened by Lord Heyworth, chairman of Unilever Limited.

Particulars of a recently-developed deep-red organic pigment, Rubine Toner 2BOS, were available on the stand of Imperial Chemical Industries, Limited, Imperial Chemical House, Millbank, London, S.W.1. The product is suitable for use in paints and lacquers of all types but is of special interest for those finishes requiring resistance to the actions of solvents and heat, particularly where lead regulations do not permit the use of scarlet chrome pigments. It is characterised by high opacity and is of special interest for one-coat industrial finishes to be used on toys and similar articles.

Pigments of high colouring power developed to offer resistance to light, heat and chemical attack were exhibited by Johnson, Matthey and Company, Limited, Hatton Garden, London, E.C.1. These materials, cadmium pigments, are available in a full range of standard colours from primrose, lemon and golden yellow, through red to deep maroon, and are stated to be unaffected by exposure to temperatures of up to 500 deg. C. in air, and to be remarkably resistant to ultra-violet light and to sulphurous atmospheres. They are also resistant to organic acids and most dilute mineral acids and are particularly resistant to soda, lime, ammonia and other alkalis. The pigments are used in the paint, rubber, plastics and other industries.

New and improved Polimul emulsions for use in the manufacture of paints were demonstrated on the stand of the Dunlop Rubber Company, Limited, Compositions Division, Fort Dunlop, Erdington, Birmingham, 24. Polimul is the name given to a range of polyvinyl acetate, copolymer and acrylic resin dispersions. These resins, of which polyvinyl acetate is at present the most widely used, are emulsified and suspended in water, and possess the important advantage of holding a high-solids content in liquid of low viscosity. This permits the easy and efficient coating of porous surfaces, with a tough, continuous film which is also stated to be light-resistant, non-toxic, water-resistant and to posess excellent ageing characteristics. In addition to their use in emulsion-paint manufacture, Dunlop Polimuls are utilised in the adhesives, leather, paper, textile, and carpet industries.

One of the main exhibits on the stand of F. W. Berk and Company, Limited, 1-19, New Oxford-street, London, W.C.1, was Bentone, now manufactured in this country by an associated company, Abbey Chemicals, Limited, Stratford, London, E.15. Bentone is the registered trade name of a class of products resulting from the chemical reaction between montmorillonite, a plastic clay-mineral and the chief constituent of bentonite, and long-chain amine salts. Bentone is described as a unique gelling agent and, when used as a paint additive, promotes improved brushing and spraying characteristics, sag prevention and long-term pigment suspension properties, without increase in the drying time or any adverse effect on the adhesion of the paint film.

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ALUMINIUM " APRON " FOR OXFORD PLAYHOUSE

The Oxford Playhouse, one of Britain's most famous repertory theatres, has recently acquired a new apron stage built of aluminium.

The new apron, which is being used for the first time on the occasion of the Oxford University Dramatic Society's production of Marlowe's *Doctor Faustus*, was designed and made at Banbury by Northern Aluminium Company Limited, and presented to the theatre on behalf of that company's employees, many of whom are regular visitors to the Playhouse. The new

apron replaces one made of timber which was cumbersome to erect and dismantle and which had become unreliable after several years' service.

The chief advantage of the new structure is that it is built up from a number of easily handled units, so that erection now takes only about half-an-hour instead of four to five hours as before; moreover, a flat surface is provided that is perfectly rigid and noiseless when walked on. The apron covers the orchestra pit, which stretches the full width of the stage, about 33 ft., and is bounded by a wall curved in an arc extending 7 ft. into the auditorium; the level of the apron is about 1 ft. below that of the stage. Support is provided by a length of extruded angle section which is fixed to the edge of the stage, and a timber rail fixed to the inside wall of the orchestra pit.

Across these extremities are laid eleven 38 in. panels (except for the centre one which is 43½ in. wide) formed completely from half-hard aluminium alloy sheet. Each panel consists of a load-bearing sheet having corrugations 2 in. deep set at 5½ in. pitch, on the top of which is riveted a flat sheet. The ends of the corrugations, which abut the wall of the orchestra pit on one side and the edge of the stage on the other, are enclosed by an overlapping channel in which hand-holes have been made and the other edges of the panel are enclosed by overlapping extensions of the top and bottom sheets.

A trap-door about 30 in. square, made in the same way and secured by two spring-loaded barrel bolts, is built into the centre panel which is suitably reinforced. This panel, the largest of the set, weighs only 60 lb., so can therefore be put into position with ease. The upper surface of all the panels is covered with a layer of felt ⅛ in. thick, secured with an adhesive and sprayed with a matt grey paint; this not only hides the brightness of the sheet but also eliminates noise when walked on.

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LOW-GRADE FUELS FOR HIGH-SPEED ENGINES

Wear Reduced by Changed Materials

The internal combustion engine industry exports between 60 and 80 per cent. of its output to some 150 overseas countries. Many of these countries, independent of Middle East fuel supplies, are making use of low-grade fuels which, unfortunately, tend to cause high rates of engine wear. To overcome this problem, the Combustion, Fuels and Lubricants Panel of the British Internal Combustion Engine Research Association has, for the past six years, been running an investigation aimed at finding ways whereby medium and high-speed Diesel engines, normally using a Class A fuel, could be made to run satisfactorily on a Class B fuel such as is generally used in the larger marine auxiliary and main propulsion engines.

Three representative types of engine were chosen and their performance and mechanical reliability were found at first to be unsatisfactory when running on Class B fuel. After numerous test runs on both Class A and Class B fuels under varying operating conditions of temperature, load, load cycle, lubrication, etc., it has been possible to assess the relative effects of such conditions on the behaviour of the engines when using Class B fuels.

By embodying certain modifications, mainly involving changes in the material of the working parts, the engines now give satisfactory performance and will run for nearly as long between overhauls on Class B as on Class A fuels.

More recently, investigations of the fundamental causes of wear have been carried out, primarily to seek an explanation for the high rates of wear associated with the increased sulphur content and carbon residue of Class B fuels.

Flame gouging instead of chipping and grinding has halved the time required to prepare the edges of hawse-pipe collars.

COMPONENT SHAPING BY FLAME GOUGING

Flame gouging is familiar in many branches of industry as a fast method of removing metal. British Oxygen flame gouging equipment is now being used for the final shaping of hawse-pipe collars in the Dundee shipyard of the Caledon Shipbuilding and Engineering Company, Limited. The collars, which are flame cut from 2 in. thick mild steel plate, using the B.O.C. Bantam machine and hand cutting, are then marked for flame gouging with lines showing the inner and outer shapes and the contours to which the operator must work. The square edges of the component, resulting from the flame-cutting operation, are then "washed" away with the blowpipe, the operator using a side to side movement which results in the correct contour on the finished collar. A considerable amount of metal is removed during flame gouging, but the finished contours are smooth and need no further treatment.

Prior to the introduction of flame gouging the components were finished by chipping and grinding, and the new method, although it requires greater skill on the part of the operator, shows a cost saving of 20 per cent. The actual saving in time is about 8½ hours, or 50 per cent., for each component.

INSPECTION OF PROFILE OR SURFACE

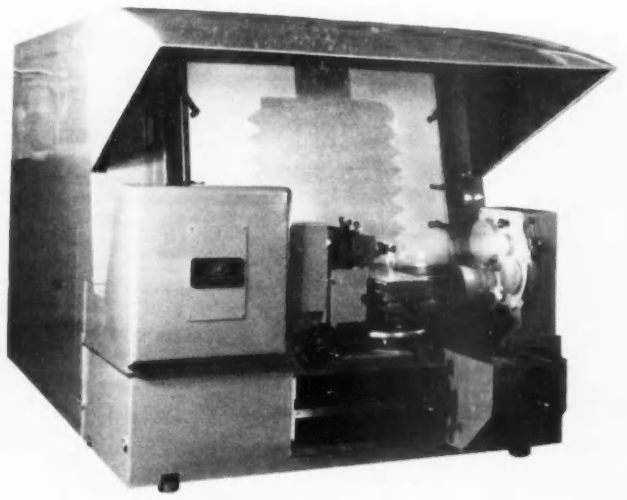
Large Dual-Capacity Projector

Inspection and measurement of both contours and surfaces are possible with the new optical projector made by Optical Measuring Tools, Limited, and marketed by their parent company, Newall Group Sales, Limited, Old Fletton, Peterborough. It is capable of dealing with contour projection work on such components as templates, gears, cams, screw threads and cutters in the normal way, and with such operations as measurement of blind holes and inspection of the work of die-sinking processes by episcopic projection, using a detachable mirror column.

In its basic form the instrument is provided with a rectangular elevating table 20 in. by 10 in., with T-slots for attaching work-holding fixtures. Four projection lenses are mounted in a turret, and another turret on the opposite side of the work-table houses the condenser lenses. Vertical and lateral adjustments are provided on the lens turret for lens selection, and there is no necessity to move the workpiece if the magnification is changed. The lenses give a 6 in. field at 10X magnifications, 3 in. at 20X, 1·2 in. at 50X, and 0·6 in. at 100X, respectively, and the image is projected on to a clear glass screen 60 in. by 40 in., which reclines at an angle of 11 deg. to the vertical for ease of viewing. Horizontally-adjustable vertical straight-edges are fitted to the screen frame, and they carry locators for the attachment, either horizontally or angularly, of a further straight-edge. Illumination of sufficient power for either type of projection is provided by a 250 volt, 1,000 watt, high-pressure mercury-vapour lamp, with forced-draught cooling in the housing.

In addition to the episcopic projection unit mentioned, the projector can be provided with several other items of equipment according to need. It can be fitted with a precision table, which is in two parts, the top section giving a 6 in. movement at right angles to the optical axis, while the lower part provides a focussing movement of ± 1 in. A measuring system using gauge blocks and a large-diameter micrometer can be fitted to the movement of the upper section of the table to enable measurements of transverse movement to 0·0001 in. to be taken. Similar equipment is available for measuring vertical movement to 0·0005 in. The upper surface of the precision table has T-slots and a V for clamping and locating fixtures.

Another accessory is a work-table assembly with centres to accommodate work up to 10 in. maximum diameter and length, and arranged for slewing through 12 deg. on either side of its



Four magnifications and a range of extra equipment enable the OMT projector to deal with many different types of work either by profile or by episcopic projection.

normal position to compensate for the helix on screw threads and hobs.

Flat form work such as punched blanks, cams and small gears, can be mounted for profile projection on a vertical glass plate which is available to order, and for supporting large work on fixtures there is a knee bracket which can be mounted in front of the projector. It has both horizontal and vertical movement.

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FISH-FINDING FROM A HELICOPTER

Tests carried out by Pye Marine Limited, Cambridge, in conjunction with Grosvenor Air Charter, during the last two months have resulted in a new method of echo-sounding from the air which is likely to have a wide application in salvage work, mine detecting and fish finding.

During the recent tests a Fishfinder, fitted in a Westland helicopter, was flown over and indicated a number of submerged objects in the English Channel. The method employed was as follows. A Fishfinder in the cabin of the helicopter was attached by a cable to a transducer housed in a specially designed bomb-shaped submarine body. This was towed on, or just below, the surface of the water at speeds up to 50 knots. In order to transmit the signal from the submarine body to the helicopter, considerable problems of cable strain had to be overcome. For safety reasons a "weak link" was provided which would break at a predetermined stress, so that the submarine body would part from the helicopter if it became entangled thereby endangering the aircraft.

The obvious implication of the device, when used in mine location, is that of safety. It is only when a minefield has been positively identified from the air that minesweepers need be called out. For salvage work the use of the Fishfinder for locating, say, a submerged submarine which is known to be within a certain area, is evident.

Support is being sought to enable further trials, under normal conditions, to take place in conjunction with fishing vessels, so that the value of the system as an economical operation can be assessed. Some 50 Pye fish detectors have recently been sold to the Soviet Union, as reported in our account of the Leipzig Fair (March 15, page 324).

RATIONALISED DIE CASTING

OUTPUT INCREASED AND DAMAGE REDUCED

The saying that pressure die casting is "the shortest distance between raw material and finished product" is probably quite well known, but it is worth repeating, as it lays emphasis on a quality which can only be exploited to the full if the process is visualised as extending far beyond the die casting machine itself. It is of little practical value to have a machine capable of turning out quality products at high speed if this advantage is negatived by slow and inefficient handling and processing afterwards. It is even worse if, by bad handling, the products are damaged, for another virtue of die casting, the ability to produce excellent surfaces, is set at nought. These were the basic considerations in planning the new pressure die casting plant at the works of the Wolverhampton Die Casting Company, Limited, Wolverhampton.

Casting, for example, is carried out on a day and night basis in order to use to the best advantage the expensive capital equipment needed, but most of the finishing operations are best suited to female labour, a fact which precludes night working in this section of the plant. The finishing equipment, therefore, has to be capable of working at double the speed of the casting machines, and means have to be provided for storing the night's production from the casters and feeding it to the finishers on the following day, together with the current production from the day-shift casters. The required balance between the casting and finishing sections is achieved by means of storage conveyors, and the handling is such that no casting ever touches another one, so the risk of damage to surfaces is eliminated.

SELF-FEEDING FURNACES

Production commences at a line of Schultz die casting machines, made by the Vincent Engineering Company, Limited, Glasgow, C.2, each one being provided with a Birlec-Tama low-frequency induction holding furnace of 20 kW capacity. Electronic control of the casting cycle ensures a consistent product. Connecting the line of furnaces is a resistance-heated launder, with a Birlec-Tama 60 kW induction furnace at each end. Ingots are charged to the two end furnaces only, the molten metal finding its own level along the launder and the line of holding furnaces. This method of feeding the metal to the casting machines has proved very successful in practice, metal losses during melting are as low as 0·3 to 0·4 per cent., and the layout is cool and clean.

It is the conveyors which connect the casting and finishing lines which are perhaps the most important items in the plant. There is a conveyor and finishing line for each casting machine, the three forming, in effect, a separate production unit, which can be re-tooled easily at the end of a production run, without interfering with the other units. An output of 500-600 pieces per hour is obtainable from each line without difficulty.

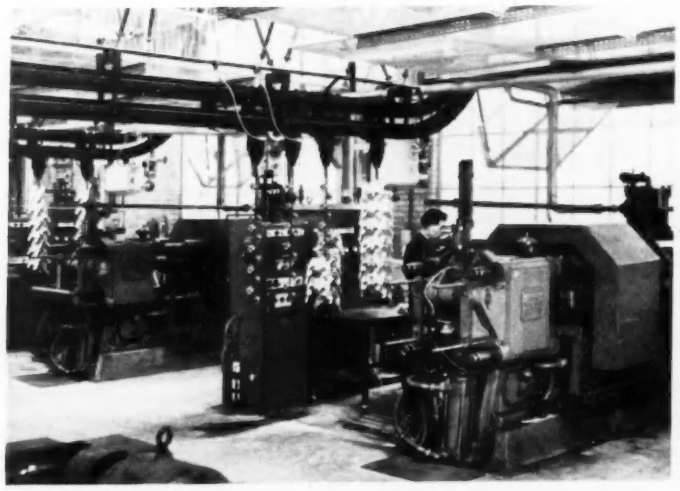
Each conveyor is 389 ft. long, most of its length being arranged overhead to act as storage space. It is a "Flowmaster" indexing conveyor made by Fisher and Ludlow, Limited, Birmingham, 12, with a continuously-running overhead chain and hangers which can be coupled into it and uncoupled automatically at the loading and unloading stations. Each hanger has a steel "tree," with staggered branches on which the castings are hung by the caster straight from the machine. As each tree is filled, it is dispatched to the storage area, and an empty one takes its place automatically.

DRAWING FROM PRODUCTION OR STORAGE

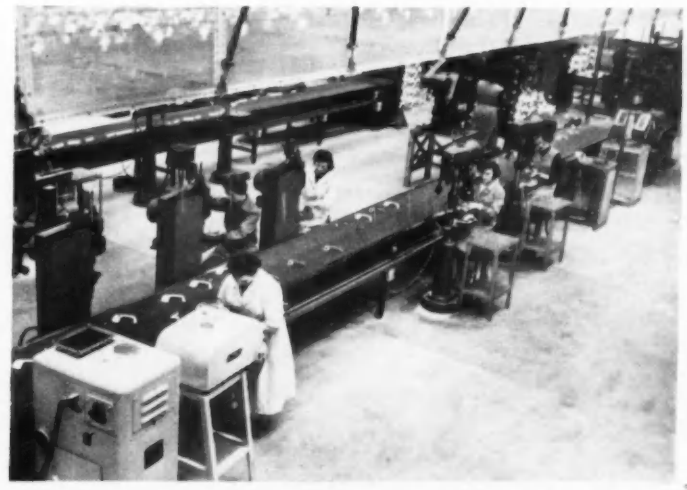
The storage area is capable, as already mentioned, of stocking the whole of a night's output from the casting machine, and the first operator on the finishing line can call carriers as required either from storage or direct from the casting machine. Normally, the procedure is to call carriers alternately from each side. The first operation in finishing is shearing off the runners in a hydraulic press, and from this point castings pass along a Fisher and Ludlow flat fabric-belt conveyor which runs between two lines of finishing machines. How the castings are dealt with here depends on the nature of the product. The machines are of the usual types for drilling, tapping and other finishing operations, and as there are take-off points at regular intervals for electric power and compressed air, the machine layout can be varied as required.

Finished castings are taken off the end of the belt and placed in special containers, in which they are dispatched. Scrap arising at the first point in the finishing line, where the runners are pressed off, falls by chute to an underground wire-belt conveyor, which returns the metal to a point adjacent to the main re-melting furnaces, where it is cast into ingots for re-use.

As a safety valve to allow for possible stoppage of a flow finishing line there is a die casting machine without the conveyors, but with a group of finishing machines capable of dealing with stock jobs. One or two operators work these machines progressively, and the bigger castings are sent normally to finishing departments in another part of the works. In the event of a breakdown on a finishing line, the operators can be transferred at once to the spare machines, and standing time is saved.



At the new plant of the Wolverhampton Die Casting Company, metal flows to a line of die casting machines in heated launders. Castings are taken away by a conveyor which will hold a whole shift's output.



The finishing lines are each served by a conveyor, on either side of which machines can be plugged in as required. Scrap runners are disposed of by an underground conveyor.

CANADIAN DE HAVILLAND DESIGN FOR TROOP CARRIER

An order for the supply of five of its new DHC4 Caribou twin-engine transport aircraft from the Canadian Department of Defence Production, on behalf of the United States Army, is announced by de Havilland Aircraft of Canada, Limited, Toronto. The aircraft are being purchased for evaluation by the United States Army. Deliveries are scheduled to commence early in 1959. The first DHC4 aircraft is scheduled to fly by the midsummer of next year. On completion of its civil airworthiness tests, it will be turned over to the Canadian Army for evaluation trials.

The United States Army has given active assistance in recent years to a number of design and research projects having as their objective the further development of STOL (" short take-off and landing ") and VTOL (" vertical take-off and landing ") aircraft. The former are aircraft in the fixed-wing category specially designed with the ability to land and take-off from short landing strips. The latter are rotary-wing aircraft able to hover, land, and take-off vertically.

An artist's impression of the DHC-4 Caribou.

The new twin-engined Caribou is basically in the DC3 load-carrying category but with take-off and landing performance designed to equal or surpass that of the Beaver and the Otter. Designed with payload and STOL characteristics as primary considerations it was a logical selection for the United States Army to add to its already large fleets of de Havilland L-20 Beavers and Otter U1-A's. Basically, it is an all-weather utility transport aircraft designed to provide rapid mobility for troops, equipment and supplies in forward battle areas, and as a commercial transport intended to offer low-cost transportation of passengers and cargo in undeveloped areas. It will be able to land or take-off from improvised landing strips as short as 800 ft. The actual take-off run, it is estimated, will be 450 ft. with zero wind.

A clear unobstructed cabin is provided with direct access through large rear-loading doors, which also permit rapid jettisoning of cargo in airborne operations. An adjustable loading ramp and freight-winching facilities provide for rapid loading and ensure a quick turn-around on the ground. These facilities, in conjunction with a payload of 2½ tons, a rapid rate-of-climb, and a good cruising speed, provide a very high work capacity in effective ton-miles per hour.

The structure is conventional, simple and rugged and is capable of absorbing a maximum of rough treatment with a minimum of field maintenance. Full-span double-slotted flaps are fitted, the outer trailing portions being independently operated as ailerons.

In keeping with the conservative nature of the project, a proven power plant has been adopted: the Pratt & Whitney R-2000 engine, of 1,450 h.p. As an alternative, the R-1820 is available, it being practically identical to the R-2000 in size and weight. Future development may be based on a propeller-turbine installation.

At a gross weight of 24,000 lb., the Caribou will have a passenger capacity of 27 seats. A strictly military bench-seat arrangement will provide seating accommodation for 28 combat troops. Cargo payloads will vary from 6,000 lb. with fuel for 600 miles, to 7,320 lb. with 200 miles range. The ultimate range with full standard tanks is 1,200 miles. As an ambulance plane, a total of 22 standard army litters can be installed.

The cruising speed is estimated at 185 m.p.h. at approximately 51 per cent. of take-off power. The touch-down landing speed will be under 60 miles per hour. The rate of climb at sea level on two engines will be 1,580 ft. per minute, and with one engine inoperative, 420 ft. per minute. The service ceiling is 26,000 ft. and the aircraft will have a single-engine ceiling of 13,000 ft.

The Caribou will have a wing span of 95 ft., and an aspect ratio of 10. The cabin dimensions are 6 ft. 11 in. wide by 7 ft. 3 in. high, giving a total cabin volume of 1,052 cub. ft.

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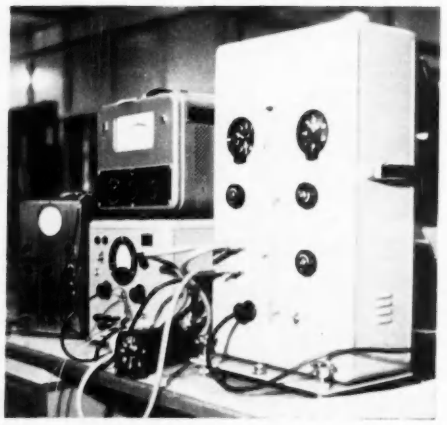
TESTING DC7.C'S CABIN PRESSURE INSTRUMENTS

Shown in the accompanying illustration is one of the test rigs for the cabin-pressure system of the Douglas DC7.C airliner. The rig was developed by Tiltman Langley, Limited, Redhill, in collaboration with British Overseas Airways Corporation, for use in maintaining the Corporation's new fleet of " Seven Seas " airliners. The aircraft equipment have to be checked for both electrical and pneumatic performance, and the test rigs comprise four separate units enabling various flight conditions to be simulated and the instrument responses to be checked.

Two of these units are designed to provide acurately-controlled air supplies for subjecting the instruments under test to pressure variations corresponding to selected cabin pressures, altitudes, and rates of climb or descent. A third unit is designed to check the electrical response of the instruments under test, and provides also a means of connecting in a vacuum tube voltmeter. The fourth unit is provided to test the amplifier used in the aircraft to interpret the electrical signals generated by the pressure-sensitive units and translate them into control signals to the inlet and outlet valves of the pressure cabin.

The pressure-controller test unit is fitted with an altimeter, rate of climb indicator, a mercury manometer and scale, plug-in points and valves for controlling suction and air supplies. The manometer is designed to give an accurate value of differential pressure and is marked on its scale the check values for the instrument being tested. Provision is made for a spill tube on each end of the manometer to prevent any mercury getting into the system, as might occur from incorrect operation by the test engineer. Before using, the test unit is levelled, adjustable feet being situated in easily accessible positions.



These four units comprise an electrical cabin-rate and pressure controller, an amplifier test set, a cabin-pressure controller and a cabin-rate controller designed for maintenance checks on the instruments of B.O.A.C.'s DC7.C airliners.

By manipulating the air valve, the altitude and rate of climb are set up on the tester and fed into the instrument under test. The electrical signals from this instrument are checked by means of the electrical test unit in conjunction with a valve voltmeter. To cater for " stiction " of the test unit instruments, provision is made for a buzzer which vibrates the instruments.

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A.C. INSTALLATIONS FOR MARINE USE

As the employment of electrically driven auxiliaries on board ship has increased and the standards of the lighting, cooking and heating services have risen there has been a corresponding increase in the size, weight and space occupied by the generators, cables and control gear. No move has, however, been made towards a more economical use of valuable raw material or to reduce the weight per kilowatt or space. Class A insulation still remains the generally accepted practice, although cheaper alternatives are available. Motors are still designed on a full-load plus sustained overload rating and control gear has become more elaborate and more costly.

This statement of the position was made by Mr. A. N. Savage in a paper " Developments in Marine Electrical Installations with Particular Reference to A.C. Supply," which he read before the Institute of Marine Engineers on March 26 and in which he endeavoured to give the marine engineer a clearer understanding of the technical, operational and economic problems which had arisen as a result. For instance, the 220 volt direct-current system, which had long been standard, was now completely out of date.

Alternators and induction motors were simpler, safer, more reliable and more economical (both in first cost and maintenance) than direct-current generators and motors. They lent themselves more readily to the employment of modern insulating materials, such as were suited to high temperatures, thus permitting further reductions in weight and bulk. Induction motors, particularly those with squirrel-cage rotors, were much less susceptible to the effects of moisture and dirt than direct-current machines. Consequently, they could almost always be of the ventilated type and be arranged for direct-on starting. The control gear required less space than with any other type of machine and its simplicity permitted the use of remote control.

The ideal system of distributing alternating current on board ship was three-phase three-wire. With this all motors of 0·25 h.p. and upwards, as well as the galley ovens and boiling plates, could be connected to 440 volt busbars. Heating and single-phase power could be supplied through 440/250 volt transformers and the lighting circuits at either 230 or 150 volts. With this system a dead-earth could occur on an essential circuit, such as the steering gear, without affecting satisfactory operation. An advantage, too, of employing a number of transformers was that the installation was divided into sections, each of which was electrically isolated from the others. An earth fault on one could not therefore combine with a fault on another to constitute a fire hazard and the short-circuit capacity of the 230 volt section was reduced, owing to the transformer reactance.

Certain items of an alternating current installation were more expensive initially than with direct current. Others, however, were considerably less; and the saving would be greater the larger the installation. The cost of maintaining an alternating current system would also be considerably less and, if properly installed, its safety and reliability would be higher.

FROZEN-STRESS TECHNIQUES

THREE-DIMENSIONAL PHOTOELASTIC STRESS ANALYSIS

By Dr.-Ing. Albrecht Kuske

The photoelastic method of stress analysis is based on the fact that transparent materials such as glass or plastics resins become doubly-refracting under the action of mechanical stress. The classic two-dimensional photoelastic technique was confined to the study of plates of uniform thickness loaded parallel to their faces only. Subsequently several methods for studying general or special three-dimensional problems have been developed, such as the " freezing " or solidifying method, the scattered light methods, the two-sheet-method and others.[1]

In the freezing method, a three-dimensional model of transparent plastics is heated so that it becomes soft like rubber. In this state the load is applied. It is then cooled slowly until room temperature is reached. When the load is removed, the strain and double-refraction caused by the load do not vanish, even in slices cut from the model. In this way, stresses and strains in three-dimensional bodies can be studied. The method is of course confined to static problems.

THE POLYPHASIC NATURE OF TRANSPARENT MATERIALS

The freezing method was actually used by several workers before it became generally known. Some of them happened to freeze thermal stresses by cooling samples of glass or phenolic resins.[2] When the freezing of stresses and strains caused by external loads was first carried out, the investigators assumed that the frozen stress and the isochromatic pattern corresponded to an elastic state of stress, but they could not explain why an elastic state of stress was produced in a plastics material.[3] The explanation was given by the author by means of a theory, fully supported by experiment, of the polyphasic nature of such materials as glass and plastics resins[4]. In order to make this phenomenon easily understood, the author established the analogy of an elastic sponge soaked with grease or a similar material. The sponge corresponds to the elastic phase of the material and the grease to the plastic one, which is hard at room temperature and gradually softens when temperature is raised.

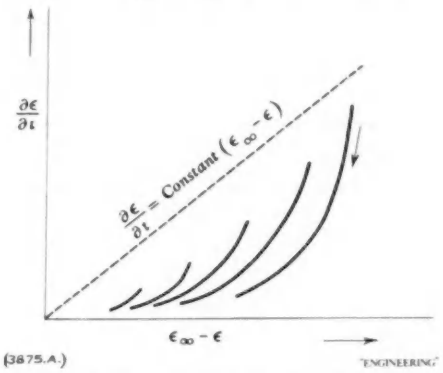

Fig. 1 Velocity of deformation of polyphasic materials.

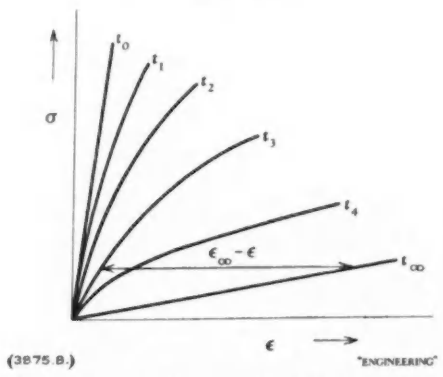

Fig. 2 Stress-strain curves of polyphasic materials, at different times after application of load.

In a later publication[5] discussing the author's experiments, another analogy was used: a system of steel springs immersed in water. At low temperature, the water is supposed to be frozen, thus producing a high modulus of elasticity, while at elevated temperature, the liquid water does not impede the deformation of the whole body. The latter analogy, however, is based on a misunderstanding of the author's theory and experimental results. It led to techniques in the freezing method which produce inaccurate results.

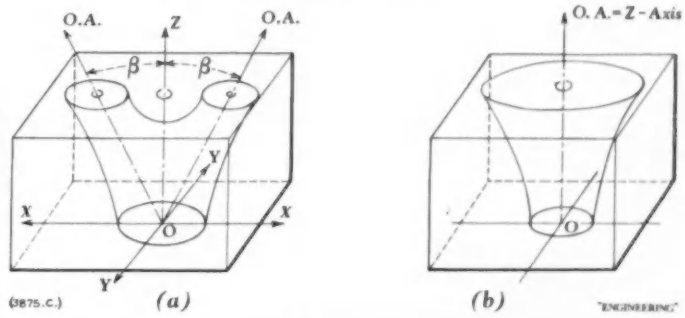

Fig. 3(a) and (b) Types of faces of equal phase difference in slices cut from frozen models.

The plastic phase of the materials mentioned does not melt at a definite temperature as water does. It can be considered as a series of materials of different melting points, thus gradually softening as the temperature is raised. It was mentioned by the author that the simple analogy based on the assumption of a homogeneous plastic phase cannot explain the phenomena of deformation at different temperatures and stresses. The most obvious deviation is observed at temperatures somewhat below the softening point when applying different loads. In the case of the simple analogy, a definite dependance of the velocity of deformation upon the difference between the momentary deformation ϵ and the final deformation ϵ_∞ which will be reached after an infinite time should exist. Actually, with a great load, the deformation is more rapid at the beginning and for some time after the application of load and then becomes lower than it should be if the simple analogy held true. (Fig. 1).

If the simple analogy were applicable for these materials the following formula should describe the velocity of deformation at any load:

$$\frac{\partial \epsilon}{\partial t} = \text{constant } (\epsilon_\infty - \epsilon). \quad . \quad (1)$$

This formula corresponds to the dotted line in Fig. 1. At least the following formula should be valid in this case:

$$\frac{\partial \epsilon}{\partial t} = f(\epsilon_\infty - \epsilon) \quad . \quad . \quad (2)$$

If this were true, the curves in Fig. 1 (and those for any other load) would coincide. But actually, as shown in Fig. 1, they do not. Consequently the stress-strain curve for these materials cannot in general be straight. Stress-strain-curves for different times after the application of load are shown schematically in Fig. 2. They are straight only at the instant, t_0, of application of the load, and after the lapse of an infinitely long time, t_∞. They are curved at all stages between these two.

The time which will elapse before a certain state of deformation is reached depends greatly upon the temperature of the experiment. At room temperature, it would take many years to reach even a partial deformation corresponding, for example, to t_3. At elevated temperature near the softening point, it takes only a few seconds to reach practically final deformation corresponding to t_∞. Excepting for this difference in time the system presented in Figs. 1 and 2 holds true for all temperatures.

In most experiments, it is not only required that the stresses and strains correspond to an elastic material but also to a material with a straight stress-strain curve (Hooke's law). Hence, care should be taken in such experiments that the strain corresponds to the curve t_∞ in Fig. 2. This means that the temperature should be high enough to ensure that the final deformation is practically reached after some time of application of load. All techniques applying " creeping " at lower or higher temperature[6] are likely to produce inaccurate results and should be avoided. In some cases, even with non-linear deformation, isochromatic patterns may be produced which seem to correspond to linear stress-strain curves, but it cannot be assumed that this will happen, and such a procedure would contradict the principles of science.

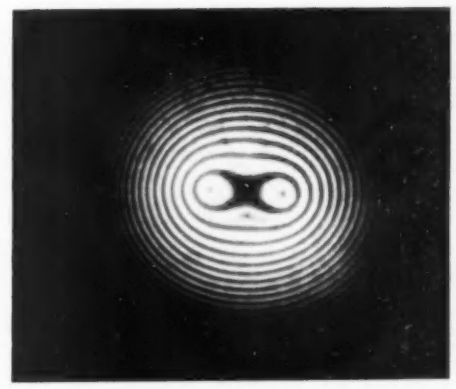

Fig. 4 Isochromatic pattern of slice in conical light; type of faces as shown in Fig. 3(a).

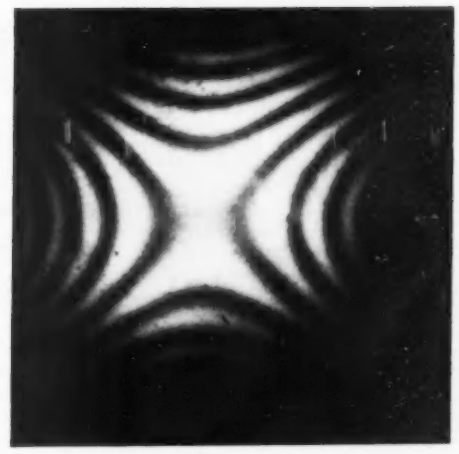

Fig. 5 Isochromatic pattern of slice in conical light; slice cut parallel to Z-axis.

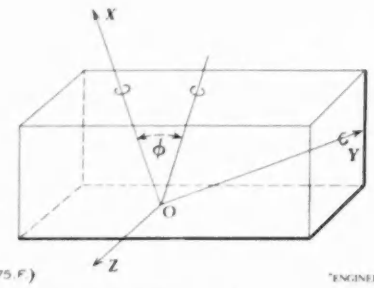

Fig. 6 Relative directions of axes and arbitrary direction of observation within X-Y-plane.

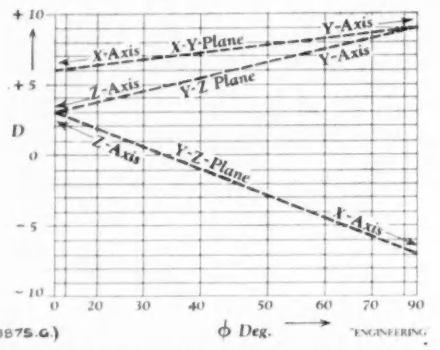

Fig. 7 Nomogram for determination of double refraction in the direction of an axis invisible by extrapolation. Double refraction D versus angle ϕ.

This deviation observed by the author has been confirmed by several others, though it has not yet been investigated systematically. The data for different materials are being investigated and will be published later on.

MATERIALS

Originally phenolic resin was the only material found to be suitable for the freezing method. Serious difficulties, however, were involved in its application, the most troublesome being the so-called edge effect.[4] Phenolic resin is chemically unstable; it polymerises, splitting-off water. The water can evaporate from a thin surface layer only, causing this layer to shrink. Hence models of phenolic resin show a system of initial stress and strain disturbing the stresses caused by the applied load. The edge effect appears within a short time when the high temperatures required in the freezing method are applied.

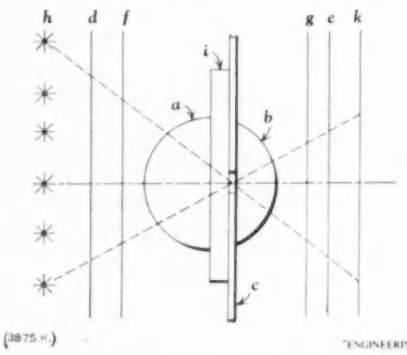

Fig. 10 Conoscope suggested by the author.

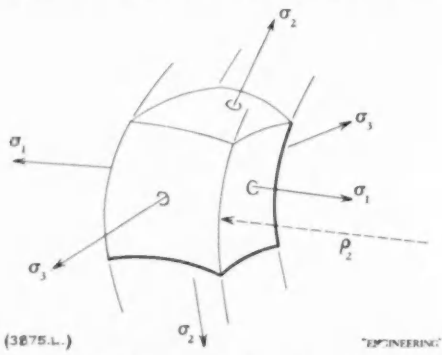

Fig. 11 Small element of a three-dimensional body cut parallel to the stress trajectories. Equilibrium of principal stresses.

Several ways of avoiding this difficulty were proposed. The first one suggested by the author[4] consisted in the use of a dummy sample, the time-heat treatment of which is to be the same as that of the actual model. The dummy is used to find the magnitude of the edge effect only, which is subtracted from the total stress found at any point (especially at the surface) of the model.

In another method, the edge effect is avoided by use of a film around the model preventing the water from evaporating.[7] A film which has proved to be effective consists of oil covered by a metal foil. It is, however, difficult to keep the metal foil tight during the whole procedure, and even the slightest slackness renders it more or less ineffective. The author[1] avoided this difficulty by immersing the model and its metal foil in oil during the heat treatment. In recent experiments, the models were immersed in mercury. This technique produced good results.[8]

In spite of these known techniques, it is

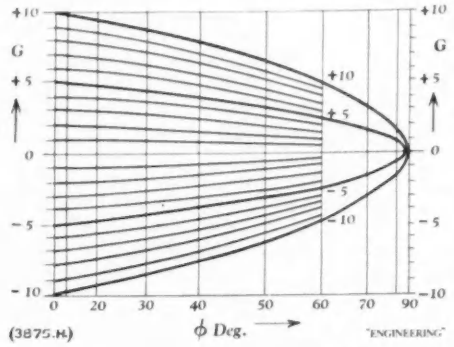

Fig. 8 Nomogram for determination of phase difference in the direction of an invisible axis. Phase difference G versus angle ϕ.

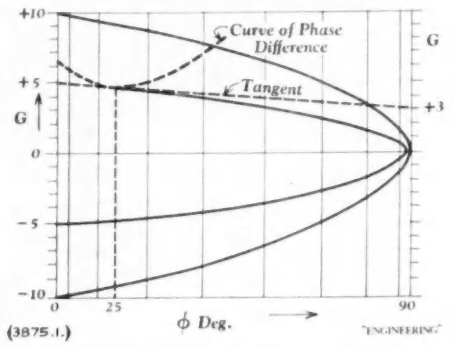

Fig. 9 Application of nomogram, Fig. 8, in case of slope of curve of stress.

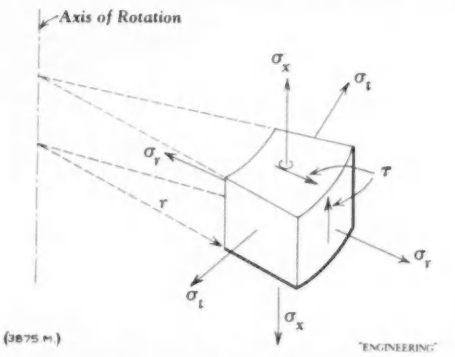

Fig. 12 Small element in cylindrical co-ordinates. Equilibrium of stresses.

desirable to have a material free from any edge effect, which affects most of the materials investigated. During the last few years, however, some suitable materials have been found to be more or less free from this disadvantage. The first one known was metacrylate (Plexiglas)* which is almost free from edge effect. The double refraction in this material is, however, much lower than in most of the other materials. Hence, special techniques in determining stresses from optical effects are necessary. These techniques had been developed by the author. They are applicable in other problems too. They will be outlined later.

Meanwhile several other materials suitable for the freezing method have been found, e.g., styrene-alkyd (Fosterite)†, polyester resins (Giessharz P1),‡ Marco§ and ethoxyline-resins (Araldite B).‖ Accuracy of results is greatly improved by the application of these materials instead of phenolic resins. A disadvantage of all of these materials is their low modulus of elasticity. In order to obtain a reasonable amount of double refraction, the loads to be applied are so great that the deformation of the models usually is much greater than that of the actual construction, thus reducing the accuracy and reliability of the results. Moreover, the weight of the models produces extra strains, which in some cases cannot be neglected. Some workers have tried to avoid this difficulty by applying temperatures considerably below the softening point, but it is an error to think that the relation between strain and frozen double refraction is increased by this method, which moreover produces inaccuracies from non-linear deformation since creep cannot be avoided in this case.

Hence the development of a material with a better relation between double-refraction and strain would be helpful to photoelasticity, although with some skill good results can be obtained with the materials available.

OPTICAL DETERMINATION OF STRESSES

Generally, the optical methods of determining stresses in the freezing method are different from those applied in two-dimensional photoelasticity. In slices cut from a frozen model, the directions of the principal stresses usually do not lie within the plane of the slices. They are unknown except in such cases as planes of symmetry or load-free surfaces of the model.

The directions of the principal stresses and the magnitude of their differences can be found by methods similar to those applied in petrography for research on natural crystals using convergent or divergent light. Additional developments were made for their application in photoelasticity.[1, 9]

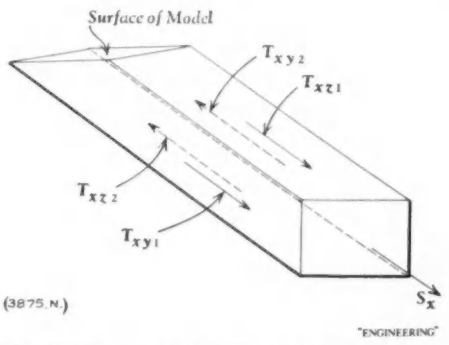

Fig. 13 Element of finite size of a three-dimensional body. Equilibrium of forces.

* Product of Röhm und Haas G.m.b.H., Darmstadt, Germany.

† Product of Westinghouse Electric Company, Pittsburgh, Pa., U.S.A.

‡ Product of Badische Anilin und Sodafabrik, Ludwigshafen/Rh., Germany.

§ Product of Scott, Bader and Company Limited, Kingsway, London, W.C.2.

‖ Product of C.I.B.A., Basle, Switzerland and Wehr-baden, Germany; and of Aero Research Limited, Duxford, Cambridge.

When polarised light starts from a point at the surface of a slice of doubly-refracting material, a face of equal phase difference will be shaped like those in Figs. 3 (*a*) or (*b*). In actual cases, the plane of the slice and the axes X, Y and Z may include any angle possible. The designation of the axes indicates their sequence as to the magnitude of double refraction observed in their directions. The Z-axis is that of the least and the Y-axis that of the greatest double-refraction. If the plane is perpendicular to the Z-axis, the intersection of the rear surface of the slice and the face of equal phase difference is shaped like the line indicated in Fig. 3 (*a*) (upper surface of the slice drawn). The lines O.A. indicate the directions of the "optical axes" (a term used in petrography). Along these lines, the double refraction is zero at any distance from the light source 0 at the front surface of the slice. The optical axes always lie in the X-Z-plane. Along any other straight line through 0, the phase difference is proportional to the distance from 0. The faces of equal phase difference of a series, e.g., λ, 2λ, 3λ (λ = wave length of the light used) are geometrically similar and circumvolve each other. A cross-section through this system of faces produces a system of lines such as Fig. 4 or Fig. 5. These photographs were made by means of an apparatus to be described later. The directions of the axes can easily be determined from the symmetry of these figures, each point of the photograph corresponding to a direction within the model slice. The magnitude of the differences of the principal stresses can be read from the photograph too. They are proportional to the double refraction of the beams in the corresponding directions. The relation of double refraction and stress value is found by a simple test in a tension or bending bar.

Usually one of the axes of symmetry only will be visible in the photographs. The double refraction, i.e., the stress difference for another axis, can be found by extrapolation. Along the planes of symmetry, the double refraction is determined by the following formula:[9]

$$D_y = D_x + \frac{D_\phi - D_x}{\sin^2 \phi} \quad . \quad . \quad (3)$$

where D_y = double refraction observed in the direction of the Y-axis, D_x = double refraction observed in the direction of the X-axis, D_ϕ = double refraction observed in a direction including an angle ϕ with the Y-axis within the X-Y-plane (Fig. 6). This formula is solved practically by means of the nomogram given in Fig. 7.[1, 9] in which the ordinates indicate the magnitude of double refraction at a certain direction, and the abscissae give the corresponding angle between an arbitrary direction and those of the two axes in the plane. The angles 0 deg. and 90 deg. indicate the directions of the axes. The double refraction plotted against the corresponding angles produce straight lines for planes between two axes in this nomogram, a fact which makes extrapolation very simple.

In another nomogram (Fig. 8)[1], the ordinates indicate the phase difference instead of the double refraction. By application of this nomogram the evaluation of the double refraction in the direction of an axis not visible is further simplified, as it is not necessary to calculate the double refraction from the phase difference before applying the nomogram. If one of the axes is normal to the plane of the slice it can be applied in the same manner as in the other nomogram. Otherwise, the length of the ordinates are to be read over an angle corresponding to the angle between the normal to the slice and the individual direction, but this length is transposed to an abscissa corresponding to the angle between the axis and the individual direction. Then in this nomogram the curves obtained for phase difference versus angle are also straight lines.

This way of determining double refraction and stress respectively is simple if the "crystal" is homogeneous. But, in most cases, the stress-curves have a certain slope both in the direction of the slice plane and in the direction normal to it. A slope in the direction of the slice plane can be eliminated by use of the nomogram.[1] The curves of double refraction or phase difference, respectively, are no longer straight lines, but are more or less curved. In order to find the magnitude of double refraction in the direction of one or both of the axes of the plane this curve is established for the individual case and the tangent to this curve at the intersection with the ordinate corresponding to the normal to the slice plane is drawn. This tangent intersects the 0 deg. and 90 deg. ordinates at points indicating the double refraction (or phase difference for a length of path corresponding to the thickness of the slice) for the directions of the axes.

In Fig. 9, this technique is demonstrated. The Y-axis includes an angle of 25 deg. with the normal of the plane. Hence, the tangent to the curve of phase difference is drawn at the intersection of the curve with the abscissa of 25 deg. It intersects the ordinates of 0 deg. and 90 deg. at a relative magnitude of phase difference of 5 and 3 respectively. These values indicate the phase difference which a light beam would undergo at a path length of the thickness of the slice. The nomogram gives only relative values. The absolute values can easily be found by comparing them with one known absolute value, e.g., the phase difference in the direction normal to the slice. In this way, the magnitude of the stresses along a line normal to the slice plane can be determined exactly, if the slope of the stress curve normal to the slice plane is zero. If, however, the stresses vary along this line an average value only can be found.

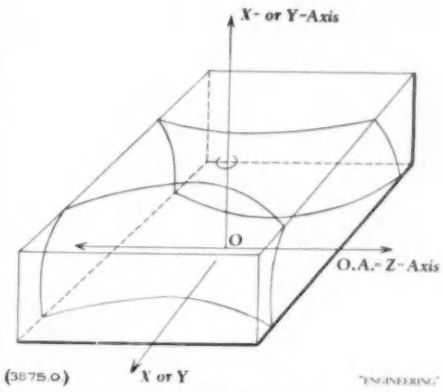

Fig. 14 Face of equal phase difference in a slice with uni-axial stress parallel to the plane of the slice.

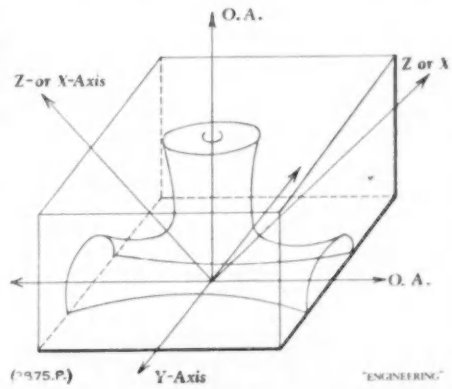

Fig. 15 Face of equal phase difference in a slice of a model subjected to pure shear.

Fig. 16 Isochromatic pattern in conical light; type of slice as shown in Fig. 15.

In such cases, the exact value can be found by application of the scattered-light method; difficulties arising from the variation of stresses along a line perpendicular to the slice plane can mostly be avoided by cutting slices in such a way that the minimum steepness of the slope of the stress curve is to be expected in the direction normal to this plane. If this is not practicable, very thin slices can be cut. In this case, the phase differences, of course, are very small. In extreme cases, not even the axes can be recognised as points of symmetry like those in Figs. 4 or 5. Hence the double refraction is to be measured by means known from two-dimensional photoelasticity, such as compensating or other means. (Compensation is accomplished by means of compensators, i.e., instruments producing a variable phase difference, the magnitude of which can be read on the scale of the compensator. The phase difference in the model is cancelled by superimposing another phase difference of equal magnitude but opposite sign by means of the compensator.) After having measured the double refraction at a number of arbitrary points (directions of beams) lines of equal double refraction can be drawn in a chart, and the points of symmetry can be found in this way. This technique, of course, is not as convenient as those mentioned above.

When Plexiglas is used as the model material the same procedure is applied to find the directions and magnitudes of the differences of the principal stresses as the phase difference will be small even if the slices are not too thin.

In special cases, such as planes of symmetry or load-free surfaces of the model, it is not necessary to use conical light in order to find the directions of the principal stresses, as one of them is normal to the plane of the slice. By observation in parallel light, however, one difference of principal stresses only can be found. Instead of conical light, some workers use parallel light with oblique incidence[10] in order to determine the second difference. The method of extrapolation is based on the same principle. The application of the oblique incidence procedure is rather inconvenient in general cases.

THE CONOSCOPE

Originally, petrographic microscopes were used for observation of slices in conical light. The ordinary polariscope with polarising filters can, however, easily be adapted for this method by means of a simple device developed by the author.[1, 9] It consists (Fig. 10) of a condenser lens *a*, a projection lens *b* and a diaphragm *c* which are installed in the polariscope consisting of the two polarising filters *d* and *e*, the two quarter wave plates *f* and *g*, and the light sources *h*. The model slice *i* is placed between the two lenses (with immersion fluid). The image of the double refraction in every direction, consisting of fringe patterns such as Figs. 4 or 5, is projected on the screen *k* which is placed in the focal plane of the lens *b*.

The necessary determination of the angles between different directions within the slice corresponding to different points on the screen is accomplished by means of a system of meridians and parallels drawn on the screen. These meridians and parallels correspond to those of a map (central projection of a globe). They are

obtained by projection from a fictitious sphere (the centre of which is the diaphragm) on to the screen. The screen can be rotated around the axis of the lens system. Two points on the screen the angle included by them to be measured are to be connected by one meridian. The angle can then be read between the parallels.

SEPARATION OF PRINCIPAL STRESSES

By means of the optical method described, the differences of the principal stresses only can be found. Though there are three axes (X, Y and Z) and three different double refractions can be found, they are not independent of each other, but the sum of two of them is equal to the third one.

In some cases, the knowledge of two independent phase differences or stress differences, respectively, is sufficient. At the load-free surface of a model, the principal stress normal to the surface is zero. Hence the two others can easily be found from the two differences.

In other cases, the knowledge of the stresses in the interior of a model is required. Even if only one principal stress or a normal stress component is to be determined it cannot be found from the optical data alone.

Several methods have been developed to solve this problem. The first one known, developed by the author, was the re-annealing method.[4]

In this method, the slices cut from the model are annealed after the determination of the optical data required. The change of thickness caused by the release of the frozen stresses is used to determine an extra value necessary to evaluate the absolute magnitude of the principal stresses. This method, though it has been successfully applied in several cases, is not too reliable. If Poisson's ratio is 0·5 the change of thickness of the slice does not supply an extra value beyond those determined optically. The extra value can be determined with greater accuracy the more Poisson's ratio differs from 0·5. Actually, in most of the model materials available, Poisson's ratio is not much different from 0·5. Hence other methods are preferred in most cases.

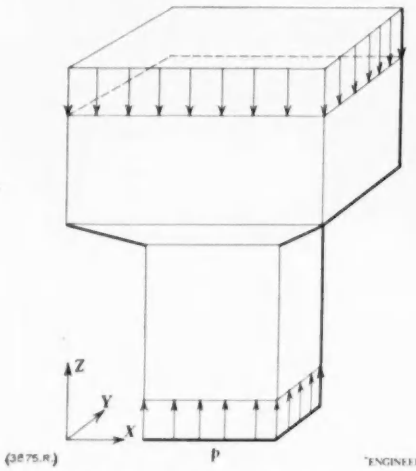

Fig. 17 Model of reinforced concrete pier, and method of loading.

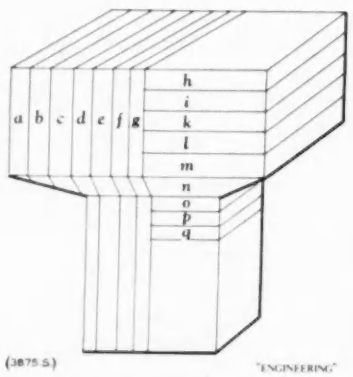

Fig. 18 Slices cut from the model of Fig. 17.

The stresses in the interior of a model can be found by integration of the conditions of equilibrium of an infinitely small element. Either the conditions of equilibrium in Cartesian co-ordinates can be applied or those of an element cut along the stress trajectories. In Cartesian co-ordinates, they read:[11]

$$\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + \frac{\partial \tau_{xz}}{\partial z} = 0 \quad . \quad (4)$$

The shear stresses τ_{xy} and τ_{xz} can be determined directly from the optical data. Thus $\frac{\partial \tau_{xy}}{\partial y}$ and $\frac{\partial \tau_{xz}}{\partial z}$ can be derived from these values. This can be accomplished with good accuracy for the shear stress within the plane of the slice, but accuracy will be poor for the direction normal to the plane of the slice.

The slope of the shear stress curve, e.g., $\frac{\partial \tau_{xz}}{\partial z}$ for this direction can be derived only from the difference of the shear stress at corresponding points of adjacent slices cut parallel to each other from the model. Their distance, however, cannot be too small as it is the sum of the thickness of the slice and the width of the saw cut. Hence the accuracy of this method is limited.

The conditions of equilibrium for an element bordered by isostatics (Fig. 11) read:[1, 12]

$$\frac{\partial \sigma_1}{\partial s_1} + \frac{\sigma_1 - \sigma_2}{\rho'_2} + \frac{\sigma_1 - \sigma_3}{\rho'_3} = 0 \quad . \quad (5)$$

∂s_1 is the length of the arc in the direction of σ_1, and ρ'_2 represents the radius of curvature of the projection of the stress trajectory of the family 2 on the tangent plane of the families of trajectories 1 and 2 (ρ_2 represents the actual radius). The principle of this method is similar to that of the former method and the difficulties are the same.

In special cases of problems of rotational symmetry, the conditions of equilibrium in cylindrical co-ordinates read (Fig. 12):

$$\frac{\partial \sigma_x}{\partial x} + \frac{\partial \tau}{\partial r} + \frac{\tau}{r} = 0 \quad . \quad . \quad (6a)$$

$$\frac{\partial \sigma_r}{\partial r} + \frac{\partial \tau}{\partial x} + \frac{\sigma_r - \sigma_t}{r} = 0 \quad . \quad (6b)$$

where σ_x = axial stress, σ_r = the radial stress, σ_t = tangential stress, τ = the only shear stress, and r = the distance from the axis.

If one slice is cut out of one half of the model so that it includes the axis of rotation and a number of slices cut normal to this axis, the conditions of equilibrium along the stress trajectories can be applied in this case without any difficulty as two of the three stress trajectories intersecting at right angles in every point of the model lie within the plane through the axis of rotation. The radius of curvature of the third one, which always is a circle around the axis, is its distance from the axis.

A method avoiding the integration of the conditions of equilibrium was developed by the

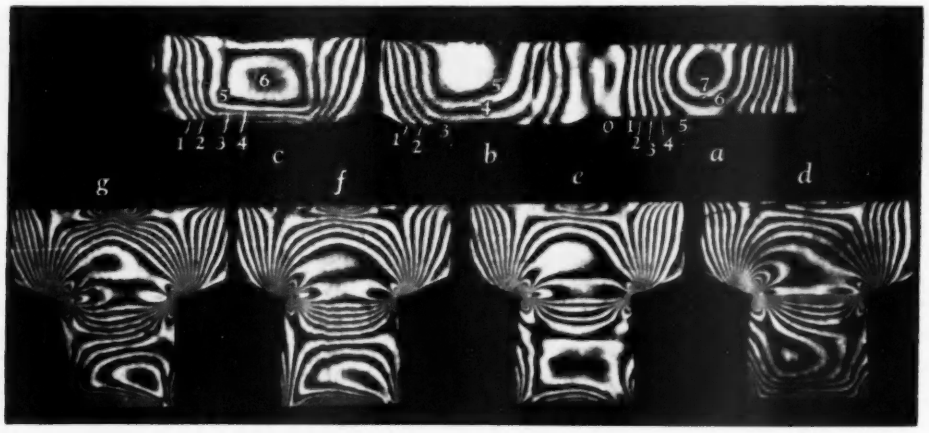

Fig. 19 Isochromatic patterns of slices *a-g*.

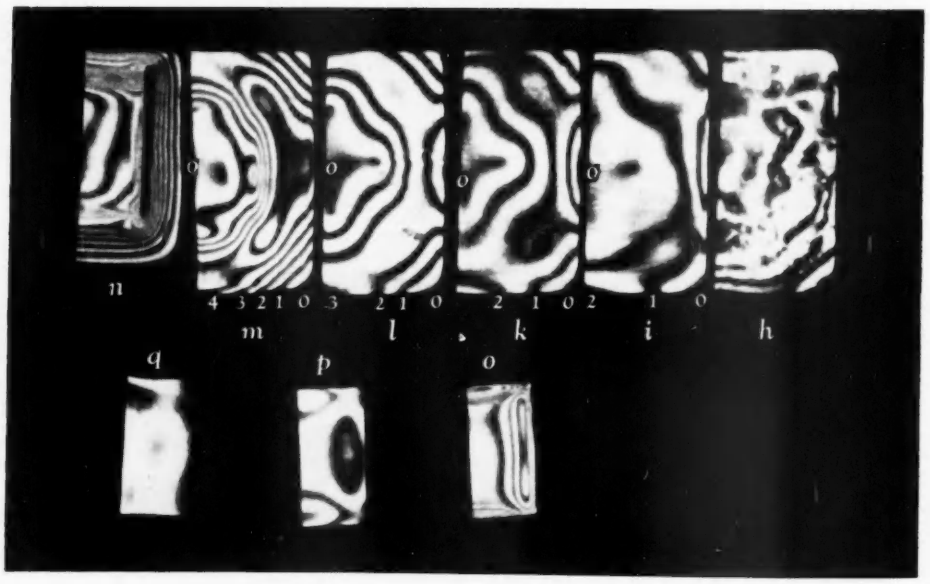

Fig. 20 Isochromatic patterns of slices *h-q*.

Fig. 21 Enlarged isochromatic pattern of slice *g*.

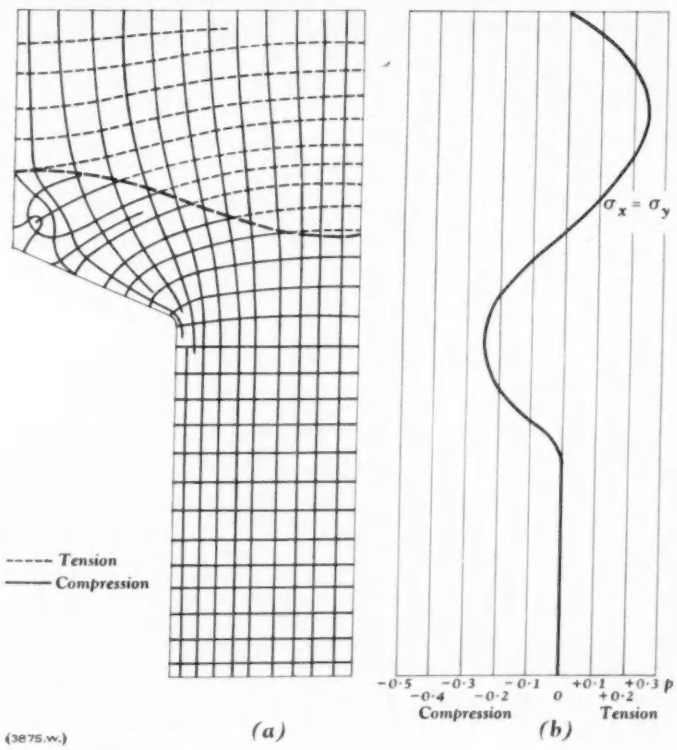

Fig. 22 (a) Isostatics in plane of symmetry.

Fig. 22 (b) Stresses σ_x and σ_y along centre line.

author for two-dimensional photoelasticity.[13] A corresponding method for three-dimensional problems uses the conditions of equilibrium of an element of finite dimensions. One of the faces of the element (Fig. 13) is a surface free from load or with known distribution of load. The conditions of equilibrium then read:

$$S_x + T_{xz_1} - T_{xz_2} + T_{xy_1} - T_{xy_2} = 0 \quad (7)$$

where $T_{xy_{1,2}}$ and $T_{xz_{1,2}}$ are the sum of the shear stresses of the surfaces of the element and S_x is the sum of the normal stress at the small front face of the element. When S_x is known the average normal stress at this face can be derived from it by dividing it by the area of the face. Applying this method, the average stresses of small rectangles within a cross section of the model can be determined. If these values are known for a number of adjacent rectangles, the stress curves can easily be drawn with good accuracy.

EXAMPLES

When in a slice cut from a model a state of pure tension or compression exists, the double refraction is similar to that of a uni-axial crystal. When the only stress is parallel to the plane of the slice, the face of equal phase difference is that of Fig. 14. The image on the screen of the conoscope is of the type shown in Fig. 5 If a state of hydraulic compression or tension is superimposed on the only stress mentioned, meaning that two of the principal stresses are equal, the same image will be produced. In other cases, too, the existence of an additional state of stress cannot be recognised from the optical data alone, but one of the methods of separating the principal stresses must be applied.

When the freezing method is applied to a pure torsional problem of a prismatic body and a slice is cut from the frozen model, the plane of the slice being perpendicular to the axis of the model, one of the principal stresses will lie within the plane of the slice; the others will include angles of 45 deg. with the plane. One of the optical axes will be perpendicular to the plane, the other parallel to it (Fig. 15). In parallel light, no double refraction can be observed, but in conical light, the image is of the type given in Fig. 16.

In other cases of pure shear, the optical axes also include right angles, and the image on the screen is of the same type as that of Fig. 16. This means that two of the principal stresses are of the same absolute magnitude but of opposite sign.

In the general case, all of the principal stresses being of different absolute magnitude, the optical axes include an angle less than 90 deg. The image on the screen is of the type of Fig. 4, if the slice is cut approximately perpendicular to the Z-axis, or of the type of Fig. 5, if the slice is cut approximately perpendicular to the X- or Y-axis. The stress in the direction of the Z-axis is that of the greatest absolute magnitude of the three stresses at that point, and the stress in direction of the X-axis has the least absolute magnitude. In case of a uni-axial "crystal," the direction of the optical axis is that of the greatest absolute stress.

The application of modern freezing techniques to a problem often involved in reinforced concrete construction is demonstrated in Figs. 17-22.

A model of a pier of the type shown in Fig. 17 was made of Araldite B. It was loaded at 140 deg. C. (284 deg. F.) as indicated in Fig. 17. After recooling, it was cut as shown in Fig. 18.

The isochromatic patterns of the slices photographed in parallel light are given in Figs. 19 and 20. An enlarged photograph of slice *g* is given in Fig. 21. The isochromatics of the section of symmetry (slice *g*) only give the differences of principal stresses, while the others generally give the differences of the stresses within the plane of the slice only (secondary stresses). The directions and magnitudes of the principal stresses outside the plane of symmetry can be determined by means of the conoscope.

The absence of the edge effect found in phenolic resins and others can be seen from the photographs. The edge effect causes the isochromatics to deviate from their natural trend near the edges. Especially in Fig. 21, which shows the model four times its natural size, the absence of edge effect can be recognised.

Fig. 22 (*a*) gives the directions of principal stresses within the plane of symmetry (isostatics). The method of shear-force differences developed by the author was applied to find the horizontal stresses within the plane of symmetry. In such cases, the application is simplified by the absence of shear stresses perpendicular to this plane.

The presence of tensile stresses is indicated in Fig. 22 (*a*). Steel reinforcement bars are necessary within the area of tensile stresses, bordered by the broken line in Fig. 22 (*a*). It would be most economical to have their directions coincide with those of the isostatics.

The distribution of the horizontal stresses along the centre line is given in Fig. 22 (*b*). The horizontal stresses σ_x and σ_y are equal at every point along this line. This can be proved by the slices *i*, *k*, *l*, *m* where $\sigma_x - \sigma_y = 0$ along the centre line. In Fig. 22 (*b*), the magnitude of the stress is given in fractions of *p* which is the average pressure in the lower part of the pier. The maximum tensile stress along the centre line is about 25 per cent. of the pressure applied. The absolute maximum of tensile stress seems to occur at another point. The horizontal stress along the surfaces can be read from the horizontal slices. In slice *m*, the maximum tensile stress is 30 per cent. of *p*.

Many other detailed results could be taken from this experiment, but these seem to be sufficient to demonstrate the techniques and to prove their efficiency.

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Book Reviews

CARRYING ON THE GOOD WORK

New India's Rivers. By HENRY C. HART. *Orient Longmans Private Limited, 17 Chittaranjan-avenue, Calcutta 13, India; and Longmans, Green and Company, Limited, 6 and 7 Clifford-street, London, W.1.* (25*s.*)

In physical formation, India consists of a great mountain wall below which lies a lowland plain formed by the valleys of the rivers Indus, Ganges and Brahmaputra. To the south of this, the Indian peninsula is formed by a great plateau much of which lies at an elevation of some 1,000 to 1,500 ft. above sea level, but which rises to about 3,000 ft. in the Western and Eastern Ghats. In general, the plateau tends to slope from west to east. This configuration, in conjunction with the climatic conditions, has determined the form and character of the Indian rivers and, incidentally, the distribution of population.

The great rivers of the northern plain are fed from the melting snows in the mountain range in the summer and by the rain and snow falling on these mountains at other times of the year. These rivers never run dry, but the régime of the peninsular rivers is very different. They have no snow storage and their performance is determined by the monsoon rains. From April to October, the monsoon winds blow from the south-west and bring heavy rains to most parts of India; the fall in the Western Ghats may amount to 200 in. These rains feed the plateau rivers which flow to the Bay of Bengal and may cause serious flooding in the lower river reaches in a wet season. Failure, or partial failure, of the monsoon rains may, on the contrary, result in famine conditions in these areas.

India is predominantly an agricultural country, and climatic conditions and the rivers, have always played an important part in her economy. In the northern plain, the main problem is to distribute water; on the plateau, it is to conserve it. There is much evidence that works to these ends have been carried out from remote times. In the Fourteenth Century, an irrigation canal was constructed to distribute some of the waters of the Jumna River, which joins the Ganges at Allahabad. In later years, many irrigation channels were dug in the northern plain. In the south, much dependence was laid on wells and tanks for storage. An example of flood protection, dating from the Eighth Century was furnished by a stone rampart built to protect the citadel situated at what is now the town of Cuttack at the mouth of the Mahanadi River in the State of Orissa.

The Indian Government in its five-year plan, extending from 1956 to 1960, has allocated an annual average expenditure on irrigation and power of some £150 million; hydro-electric installations are associated with river control and dam building, and the proportion of the total sum devoted to river works cannot be stated separately. A policy of river control on present-day scale, with its bearing on agriculture and famine prevention, is not novel. It was inaugurated, and made important progress, under the British régime; sufficient evidence is furnished by the Mettur Dam on the Cauvery River in Madras, and the Sukkur Barrage on the Indus, which is now in Pakistan.

The present Indian Government is showing great energy and courage in the control and development of the rivers of the country and this book is somewhat in the nature of a paean celebrating that activity and energy. Mr. Hart does not pretend to present a complete picture of this aspect of Indian development; he deals with selected examples. The book is not an engineering treatise. The author is Associate Professor of Political Science in the University of Wisconsin and his interests are presumably mainly sociological. He describes the engineering features of some of the dams with which he deals in popular language, but the main interest of the book lies in his account of the political background. Although the leitmotiv of the book is the devoted purpose of the rulers of the new India, Professor Hart does not hesitate to deal with the local interests and jealousies controlling, and frequently hampering, progress.

Under its present constitution, India is a federation of individual States; governmental powers, executive, legislative and judicial, are distributed between the centre and the units. An interesting example illustrating the results which may arise from such localised authority was presented by the building of the dam on the Pungabhadra River. Professor Hart deals with this matter in some detail. The river forms the boundary between Hyderabad and Madras and agreement between the two States about a common project, of great importance to both, proved impossible. Finally, each State decided to build its own half of the dam, and did so. Professor Hart also gives much information about the Hirakud Dam, which was inaugurated by Mr. Nehru in January. Much credit has rightly been claimed for Indian engineers in connection with this dam; this credit Professor Hart adds to, but fails to mention that the dam was planned, and the beginnings of the foundation laid, during the British régime.

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FUEL SAVING

Boiler Plant Instrumentation. By W. R. L. KENT and D. C. GUNN, in collaboration with G. F. J. MURRAC. *Heywood and Company, Limited, Ingersoll House, 9 Kingsway, London, W.C.2.* (21*s.*)

This book is limited to considerations of the smaller industrial steam raising plants and, as the title implies, the purpose is to show that optimum efficiency in the utilisation of the latent energy in coal and oil cannot be attained without adequate instrumentation. The authors are entirely successful in proving their point.

The statistics given in the first chapter—appropriately entitled "The Basic Problem"—are most revealing and indicate, in no uncertain terms, the importance of the small boiler in the industrial life of the nation. It is estimated that there are between 50,000 and 100,000 small boilers at work in the United Kingdom, using about half the total quantity of coal burnt for steam raising. The remainder is used by the Central Electricity Authority. The significant factor is that, while the large plants have an average boiler efficiency of the order of 80 per cent., a survey—quoted elsewhere in the book—reveals that small boiler houses lacking in instruments have an average efficiency of 61 per cent., while adequately instrumented ones have an average efficiency of 75 per cent. It is estimated that if all boiler houses were to attain the higher efficiency figure, a saving of about $7\frac{1}{2}$ million tons of coal per year would result. It is rightly pointed out that efficiency in the boiler house is but a part of the problem; by using steam more efficiently in the factory outside the boiler house, even more significant savings would be obtained.

The main virtue of this book lies in the fact that its message appears to be directed towards managements rather than the professional combustion or instrument engineer—and the incentive for spending money on equipment to promote efficiency must, of course, emanate from the managements.

The general position concerning small boiler plants having been dealt with, without overlooking the implications of the "Clean Air Bill," the next chapter is devoted to brief descriptions of the various types of boilers in common use. A reader not well versed in this subject will readily grasp the fundamental principles from the text and diagrams. The following two chapters deal, respectively, with solid and liquid fuels and the appliances used for burning them. For liquid fuels, brief notes are given concerning controls and safety devices.

The first four chapters clear the ground for the main subject—why instruments are so important in promoting efficiency. In the remainder of the book, one chapter is devoted to a discussion on what measurements should be made, and the next—the longest chapter incidentally—deals exclusively with industrial measuring equipment and describes the operation of steam and water flow meters, temperature measuring instruments, percentage CO_2 and O_2 recorders, and smoke density measurement. The next chapter deals with the use, installation and maintenance of instruments. Unquestionably, installation and maintenance are of supreme importance—if these items do not receive the attention required, it is simply a waste of money buying instruments and there are no prospects of increasing efficiency. Some very good advice is given in this chapter, e.g. that an agreement for periodic service should be entered into with the suppliers of instruments and similar equipment.

The penultimate chapter of the book is concerned with the automatic control of small boiler plants. It is, of course, quite impossible to deal fully with automatic control in the space of a few pages; so, after a brief outline of the basic principles involved, the remainder of the chapter is devoted to the description of a number of systems in common use—electric, hydraulic and pneumatic. The book concludes with a very short chapter—barely two and a half pages—on incentives and methods of making the best use of instruments and automatic controllers. With advantage this could have been extended.

Throughout the work no mention is made of the critical steam pressure gauge; it is implied that changes in load can be followed from steam flow meter readings. While this is true, it is generally agreed that steam pressure is the criterion giving immediate indication of change in steam demand. It is for this reason that all automatic boiler control systems rely on the value of the steam pressure to initiate the necessary corrective actions, the controlling element being commonly referred to as the "master controller." In dealing with flue-gas analysis, while equipment for measuring percentage O_2 is described, virtually no space is devoted to

considerations of the reasons why the present trend is towards using this measurement instead of percentage CO_2. Data might have been provided concerning the relationship between percentage O_2 and percentage excess air.

This volume—entirely non-mathematical in character—will prove a useful addition to the library of executives and others interested in boiler house efficiency, serving both as a general guide to the techniques involved and as a reference book when boiler house efficiency is under discussion. A comprehensive bibliography is included.

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NEW BOOKS

Glasfaserverstärkte Kunststoffe: Herstellung, Eigenschaften, Prüfung Anwendung der modernsten Kunststoffe auf Basis von Glasfasern. By H. HAGEN. *Springer-Verlag, Reichpietschufer* 20, *Berlin W.*35, *Germany*. (48.60 *D.M.*)

To meet the need for literature in German on fibreglass reinforced plastics, the author sets out the present position of knowledge on the subject. His book is based mainly on existing British and American works, combined with experience gained during a study tour in the United States. Possibilities and limitations are given as a guide to constructors using the material, while the technical information and production methods are of interest to manufacturers. After dealing with the raw materials used, the physical properties of fibreglass reinforced plastics are examined, and manufacturing processes are explained, as well as machining and finishing operations. The use of the material as a constructionalel ement and methods, of testing and measuring essential characteristics, are also aspects receiving attention. There are a number of examples of the very varied uses for this type of plastic which is considered to have a potential market liable to continual expansion.

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TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Continuous Mining. JOY-SULLIVAN, LTD., Cappielow, Greenock, Scotland. Details of the Joy "Continuous Miner," which rips coal from the coal face and feeds it, by means of an integral conveyor, to a shuttle car or conveyor for transport to the shaft. The machine is available in a range of sizes, to suit different seams, and has a very high rate of output—the peak rate of simultaneous cutting and loading being about 2 tons per minute. Illustrated brochure, which also gives details of some other Joy-Sullivan machinery such as conveyors, shuttle cars and loaders.

Solid Reamers. CLARKSON (ENGINEERS) LIMITED, King Edward-road, Nuneaton. Solid shank reamers, for autolock or taper shank mounting, up to $1\frac{1}{4}$ in. in diameter, and shell reamers from $\frac{5}{8}$ in. to 2 in. in diameter. Available either ground with a tolerance of 0·0002 in. for reaming to B.S.S. or Newall limits, or ground below size to enable correct size to be obtained on the final grinding operation. Illustrated leaflet.

Cooling Water. BRITISH INDUSTRIAL PLASTICS LTD., Tat Bank House, Oldbury, Birmingham. Cooling water for moulding presses can also be used for subsequent space heating with or without a heat pump. "The Economical Use of Cooling Water" describes experimental work carried out on this subject from the point of view of fuel economy, and gives facts and figures.

Tool Making, Contract Machining and Machine Tool Re-building. NASH AND HODGE ENGINEERS, LTD., Summit Works, Woodbridge, Guildford, Surrey. Details of three complementary services, which cover jig, tool and fixture manufacture, small and medium contract machining, and the re-building of machine tools to makers' or Schlesinger limits. Illustrated brochure.

Lighting Service. GENERAL ELECTRIC COMPANY LTD., Magnet House, Kingsway, London, W.C.2. "The Reality of a Complete Lighting Service" describes the Osram lighting service that has been built up to cover domestic, industrial, and commercial needs. Many examples are given of both indoor and outdoor installations. Booklet.

Solenoid Flow Valve. BIRFIELD INDUSTRIES LTD., Stratford House, Stratford-place, London, W.1. "Flowmax" valve for hot or cold water systems; solenoid operates a pilot plunger only, main valve is lifted by the water pressure. Made in three sizes, $\frac{3}{8}$, $\frac{3}{4}$ or $1\frac{1}{4}$ in. Suitable for pressures up to 150 lb. per sq. in. Leaflet gives details.

Boiler Control. JAMES GORDON & CO. LTD., Dalston-gardens, Stanmore, Middlesex. Automatic control apparatus for oil-fired boilers, regulating both air and oil. Equipment for large and medium boilers described in leaflet No. 111; simplified version (specially suitable for marine installation) in leaflet 112.

Felt Mops and Washers. COOPER AND CO. (BIRMINGHAM) LTD., Brynmawr, Breconshire. Coopers, makers of technical and industrial felts, have acquired James Farrer and Sons Ltd. of Sheffield, makers of polishing and grinding equipment. Various leaflets describe polishing mops and felt washers and pads.

Multi-Cell Dust Collector. W. C. HOLMES AND CO. LTD., Turnbridge, Huddersfield. Holmes-Rothemule multicell cyclone dust collectors give 90 per cent. efficiency for particle sizes down to about 12 microns with a pressure drop of less than 1 in. of water at flows up to 700 ft. per min. Publication 68.

Boiling Controller. SPIRAX-SARCO LTD., Cheltenham, Glos. Controllers for bowl and instrument sterilisers which automatically adjust the supply of steam so as to maintain boiling. Two types, with and without automatic steam cutout if the lid of the vessel is raised. Pamphlet No. 127.

Machine Tools. W. E. SYKES LTD., Manor Works, Staines, Middlesex. "Service to Industry" gives a history of the company and mentions some of the tools they make and services they offer. Gear generation is described in particular. Booklet.

Engraving and Machining. MILLETT, LEVENS (ENGRAVERS) LTD., Stirling Corner, Barnet By-Pass, Borehamwood, Herts. Engraving, light engineering, printed circuits, and electronic work. Booklet describes capacity available and specialised lines.

Draught Fans. STURTEVANT ENGINEERING CO. LTD., Southern House, Cannon-street, London, E.C.4. Performance curves for various types of mechanical draught fan, with examples of their use and nomograms for calculating volumes. Booklet 3502.

Oil-Water Separation. MOBIL OIL CO. LTD., Caxton House, London, S.W.1. Industrial technical bulletin No. 21 describes methods of removing water from barrels of oil.

On the Shelf

By Frank H. Smith

It is remarkable that in the United States of America, where the cost of living is reputed to be so much higher than it is in this country, students (one of the poorest classes in any community) should be able to get standard text-books at a fraction of their cost in this country. This state of affairs is due to the enterprise of Dover Publications Inc. who, for years, have produced "paperbacks" at a price well within the range of shallow pockets.

Two of their latest titles are fair examples. They are A. A. Klaf's "Refreshers for Technical Men" on trigonometry and calculus. Each costs only 1.95 dols. A full list of the works available in the series—which includes Agricola's *De Re Metallica*, Born's *Experiment and Theory in Physics* and Temple and Bickley's *Rayleigh's Principle* among others—can be obtained from the publishers at 920 Broadway, Department TF4, New York 10.

The first edition (1956) of a useful new book is "British House Journals." (The British Association of Industrial Editors, 12 Thayer-street, London, W.1.) It lists the publishers of the majority of such periodicals together with their titles. Some people throw house journals in the wastepaper basket, either immediately or after a short period. In many cases this is very foolish, because the better produced house journals contain excellent articles on new developments. I have been able to provide, on more than one occasion, house journals of the 1920's containing information that could be found nowhere else. One must discriminate of course.

Work study is a subject on which it is difficult to find many references and it is pleasing to see that a new journal (January, 1957) entitled *Work Study and Industrial Engineering* has been launched by Management Publications Limited. The first number (price 2*s*. 6*d*.) contains three articles by authorities in their fields and also a useful bibliography on method study, prepared by Manchester Public Libraries. The journal will appear monthly.

Another periodical that has appeared in recent months is *Automation Progress*. The aim is to keep busy executives and engineers abreast of the latest developments. In view of the amount of scattered literature on automation this magazine should prove a boon, particularly if it could review, each month, worthwhile articles and papers that have been published since the previous issue.

Unlike automation, which is recognised everywhere as having come to stay, solar energy is a branch of engineering on which it is very difficult to find references. The Association for Applied Solar Energy seeks to put that right with *The Journal of Solar Energy Science and Engineering*. The headquarters of the Association are at Arizona. This is an authoritative and informative journal and its contributors are drawn from all parts of the world—including the Russian Academy of Sciences, whence comes an article on "High-Power Solar Installations."

The merits and defects of abstracts have long been a source of argument between librarians and other users. The most argued points are whether the abstracts should be informative or indicative, critical or objective. If the indicative abstract is reduced sufficiently, it is reduced to just the title. Is this enough? Those who think it is are catered for in a new service called the Index of Technical Articles (IOTA), number 1 of which appeared recently. It claims to be a list of all the important articles that have appeared during the past month in a wide range of British technical periodicals and a few of the leading daily newspapers. The items are arranged in a modified Universal Decimal Classification order. The cost is three guineas for six months.

Probably no subject has amassed a huge bibliography in such a short time as has atomic energy. A most useful document, "Sources of Information in Atomic Energy," has been compiled by Mr. L. J. Anthony of the Atomic Energy Research Establishment, Harwell. He has divided the sources into British, American, Russian and "other countries." It must be emphasised that this is a review of *sources;* it is not a detailed bibliography. An appendix lists some publications.

"Glossy magazines" are not associated with science and technology but I put some of the more esoteric publications in that field. A newcomer is *Combustion and Flame* from Butterworths. It is the quarterly journal of the Combustion Institute and is produced as a sister-journal to *Fuel*. It will be seen that there is a nice difference in the audiences which they cater for.

The monthly "B.S.I. News" of the British Standards Institution usually has at least one item to interest the individual reader. The February number has particulars of a revised standard of outstanding importance to all concerned with the printed word. A revised B.S. 1000A, "Abridged English Edition of the Universal Decimal Classification," has been produced and it is certainly a considerable expansion of the 1948 version. Its index can be bought as a separate item and this contains some 20,000 entries, which is about 10 times the number of the first edition. Incidentally, the 1957 edition of the *B.S.I. Yearbook* is now available at 15*s*.

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FAST-THERMAL REACTOR

Two-Region Critical Assembly for Breeder Studies

Breeding, whereby more fuel is produced than consumed, is obviously a desirable quality in a power reactor. Stability too is an important consideration, but the fast reactor, which provides the basis of breeding systems, presents certain control problems which have not yet been fully solved. Thus, if the stability of a thermal reactor could be combined with the neutron properties of a fast reactor, the composite result would be extremely attractive. Both Britain and the United States are studying such a system, probably with a view to the eventual design of a power reactor. Last week we referred in Atomic Review to the Harwell experimental reactor ZEPHYR, which is being used for these studies, and on February 1 and March 1 to the two-region zero-power reactor ZPR-5 at the Argonne National Laboratory, U.S.A. The more comprehensive description of ZPR-5 published below is the substance of a paper by F. H. Martens, F. C. Beyer, H. H. Hummel, D. Meneghetti and B. I. Spinrad, presented at a meeting of the American Nuclear Society in Washington, D.C., last December. Certain terms used are explained in Atomic Review. Acknowledgment for the illustrations is made to the Argonne National Laboratory.

Outline

ZPR-5 (Zero Power Reactor—5) is a zero power critical assembly built in order to study some of the physics properties of a fast dilute reactor system. The system is composed of two regions: the fast internal section, and a thermal section which surrounds it. The loading of the central section is extremely flexible, allowing studies on a wide range of fuel enrichments and concentrations of fuel, coolants, and structural material. No more than one-half of the total reactivity of the system will be contained in the fast core. This arrangement was chosen to eliminate certain possible dangers of a fast system and to reduce the large fuel inventory necessary for a complete fast reactor system. The surrounding thermal annulus is a light-water moderated, enriched uranium system. Neither the fast nor the thermal section is critical separately, but the combined system is critical. The system has a thermal reactor lifetime and is controlled as an ordinary thermal reactor. The facility is being used to study the neutron energy spectra, breeding ratios, fission ratios, and flux distributions in various core configurations, and the reactivity effects of different materials in these configurations.

Fast Reactor Experiments

ZPR-5 is the third major assembly in the Argonne National Laboratory's programme of research into fast dilute reactors; it is illustrated in Fig. 1. The first was the Fast Exponential Experiment, described in the United States publication ANL-5379. The second is the Fast Critical Assembly, described in ANL-5513.

The experiments on ZPR-4, the Fast Exponential Experiment (shown schematically in Fig. 2), gave excellent results for materials buckling of homogeneous assemblies; it also gave very good results in connection with the fission ratios between the various materials. This was the best spectral information that could be obtained because the extremely leaky system and the low power limit at which the assembly was operated prohibited the removal of a neutron beam from the assembly to use in a beam-type spectrometer. Also, because of the extremely low reactivity value of the exponential assembly, danger coefficient measurements were almost impossible. These limitations led to the development of ZPR-5 in which the exponential assembly was placed on the inside of the driving thermal reactor. An idealised version of ZPR-5 is shown in Fig. 3. There, the fast section is surrounded by an isolating blanket to give a better neutron energy match between the two sections. In this configuration the statistical weight of the fast assembly has been increased to 50 per cent. of the total reactivity.

Central Region

The idealised reactor has in reality the general form indicated in Fig. 4. This diagram represents a plan view of ZPR-5, which is a two-region critical assembly. The central region is the fast region, containing about 18 per cent. of the reactivity, and is located in a central tank which is 22 in. square. It is made up of no more than 49 fuel cans, each 3 in. square in cross section. These cans can be filled with any desirable percentage of uranium, coolant, or structural material, as shown in Fig. 5. This material is in the form of thin plates, and by varying the number of plates, the concentrations may be changed. To begin, experiments will be performed with 35 per cent. uranium, 10 per cent. iron, and 14 per cent. aluminium, which is the equivalent of 55 per cent. sodium; this will leave about 40 per cent. void. The cans rest directly on the bottom reflector consisting of 6 in. of natural uranium backed by 6 in. of iron, which in turn rests on a supporting framework, as can be seen from Fig. 6. A plan view to a different scale appears in Fig. 7. If, in the very improbable case that any water entered the central region, it would flow around the bottom reflector and into the void below the support and out through a 3 in. line on to the floor. This is included to eliminate the possibility of water standing in the central region. The upper reflector, consists of 4 in. of uranium and 8 in. of iron. It is attached directly to the fuel cans to prevent the sudden addition of an upper reflector, which might prove to be embarrassing. The cans take up 21 of the 22 in. across the central tank. The other inch is left to provide room for detectors or instruments. A fuel can is shown being lowered into place in Fig. 8.

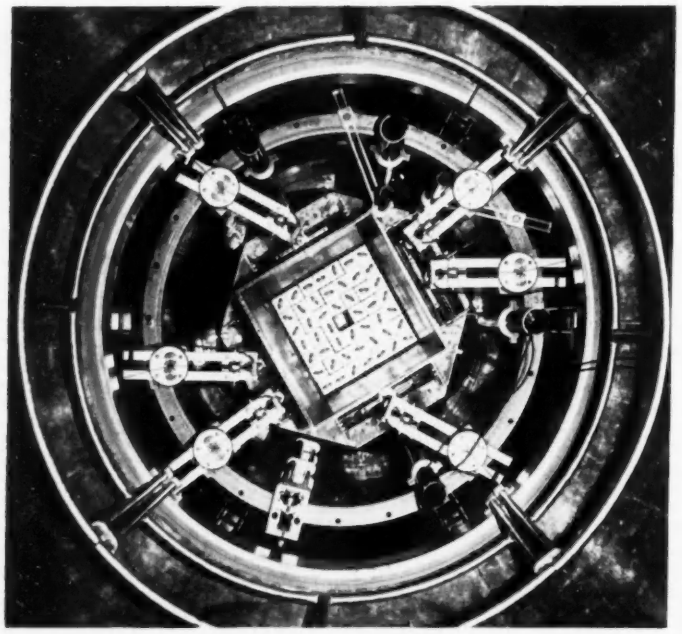


Fig. 1 View of the two-region zero power reactor ZPR-5 at the Argonne National Laboratory. A controlled thermal reactor surrounds a fast central core, neither section being critical alone. Power reactors based on this system may eventually be developed.

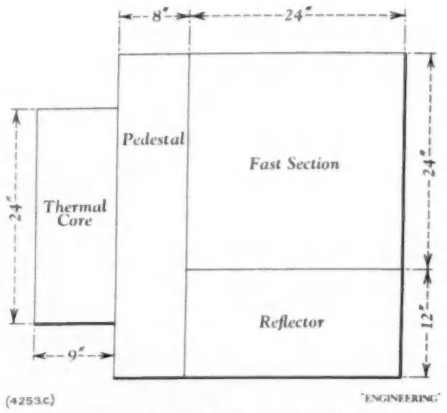


Fig. 2 Schematic representation of the fast exponential experiment ZPR-4, which led to the development of ZPR-5.

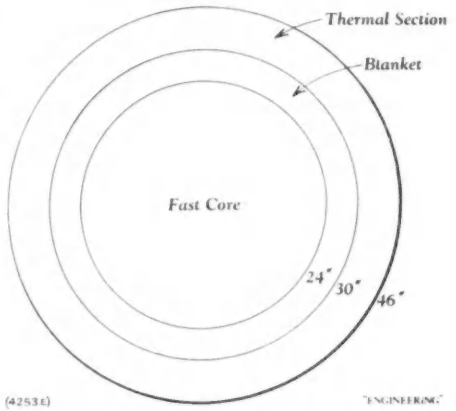


Fig. 3 Idealised version of ZPR-5. The two region systems combine the kinetics of the thermal reactor, and hence ease of control, with the breeding properties of a fast reactor.

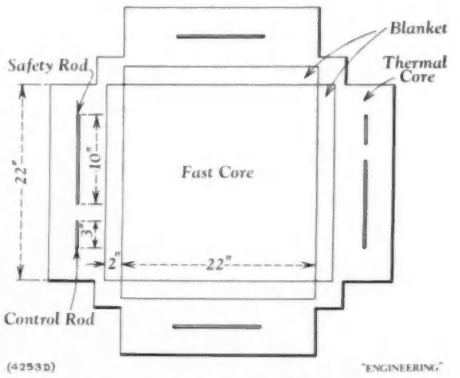


Fig. 4 Diagrammatic plan showing general arrangement of ZPR-5. It is said to have a lower fuel inventory than fully fast reactors.

Four Thermal Regions

The thermal region is actually four separate regions, one located on each side of the fast core.

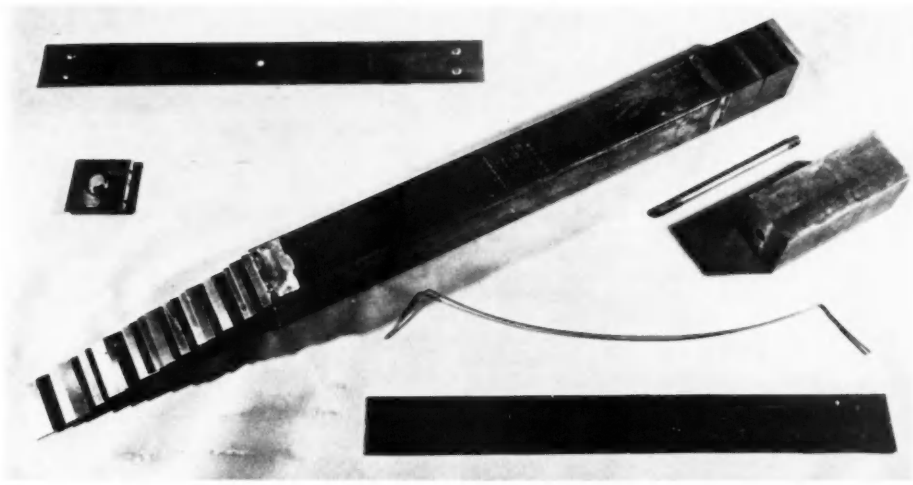


Fig. 5 Exploded view of exponential fuel can for fast central region of reactor. These cans may be filled with any desired percentage of uranium, coolant, or structural material in the form of thin plates to simulate any given operating conditions.

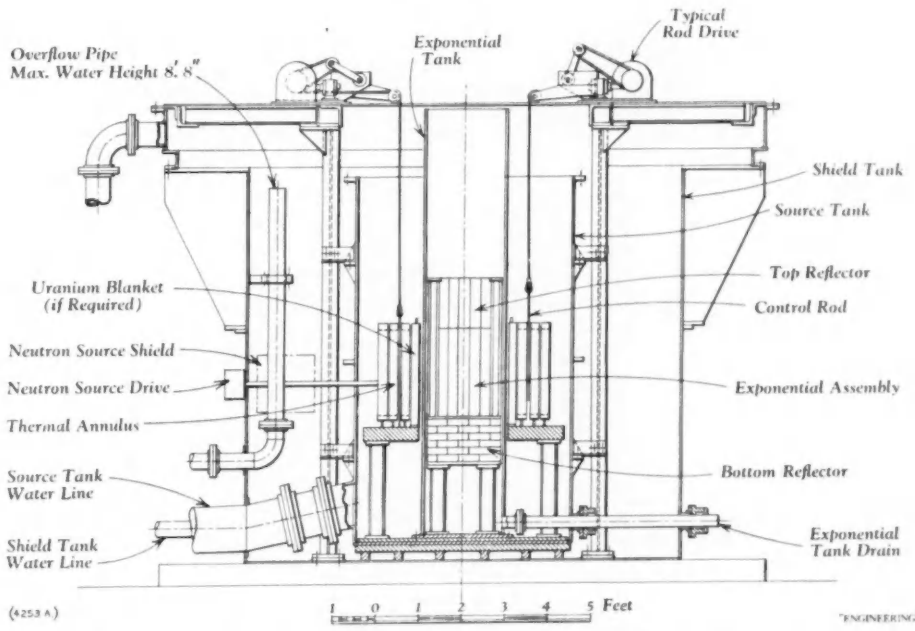


Fig. 6 In the fast region the fuel cans rest on the bottom reflector, comprising 6 in. of natural uranium backed by 6 in. of iron, which rests on a supporting framework.

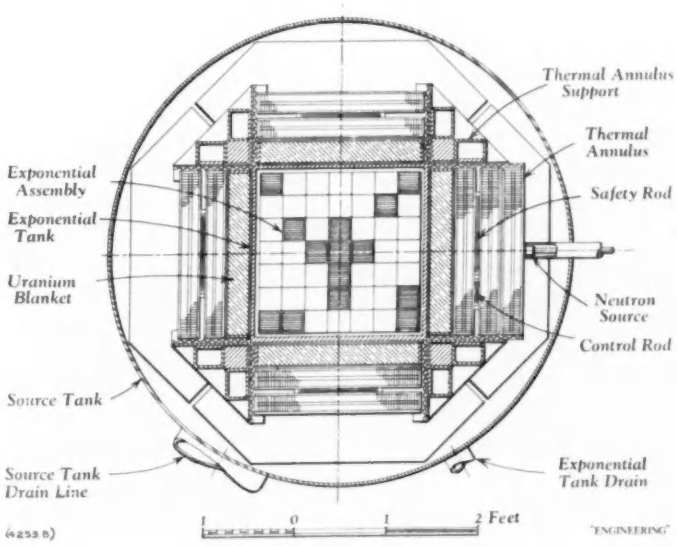


Fig. 7 (left) Plan view of internal exponential or fast region of ZPR-5.

Fig. 8 (right) A fuel element consisting of uranium and other materials is shown being lowered into the fast region of the compound reactor.

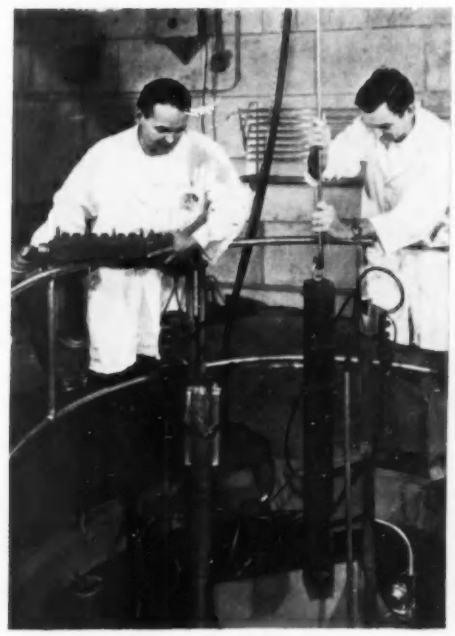
The fuel for this region is in plates consisting of approximately 16 grams of uranium 235 alloyed with aluminium and jacketed with aluminium. A total of 2,200 grams of uranium 235 may be located on either side of the reactor. Between the two rows of fuel plates there is a safety rod, and on two sides, a control rod. Both the safety rods and the control rods drop in an emergency. In the fully loaded thermal region there is a metal to water ratio of 0·4 to 1. There is approximately 7 per cent. shutdown available in the safety and control rods, and when the water is dumped the reactivity is well below 10 per cent. The top of the central region is approximately 9 in. above the thermal annulus tank. Water is pumped into the thermal annulus until it reaches the top of the tank. From there it flows over into the shield tank and through the shield overflow back into the storage tank. Only a small amount of water is added to make up for any leaks in the system. This water in the thermal tank is released in an emergency through a 12 in. dump line. After the first seven seconds the water is down below the top of the core, certainly shutting off any reactivity effects of the water.

Safety Devices

Several interlocks prevent unsafe operation of the reactor, the main one being the door interlock which dumps the water and control rods whenever anybody enters the assembly room. Other interlocks prevent the withdrawal of rods without sufficient neutron flux for start-up, or before the water is completely up to the required level, and before the safety rods are withdrawn. In order to raise the water as quickly as possible, and still maintain safety, an automatic fill control was installed. This permits the water to be pumped at a high rate whenever the increase in height is not adding appreciable reactivity. Whenever the water is level in the core region, the pumping is carried out at a very low rate, so that a specified rate of addition (0·05 per cent. k per sec.) is not exceeded. A pair of counter balancing weights, one of which rides on the surface of the water, turn a 10-turn potentiometer, which feeds a signal into an amplifier and a relay system; the relay system serves to open and close the valves at the proper position. They also operate a meter located on the control panel to show water level. In addition to this indication there is a sight level gauge in view of the operator.

Experimental Programme

A flux-mapping device, shown in Fig. 9, can be used to move a detector through the reactor. The detector may be raised to any particular level and also moved across the fast



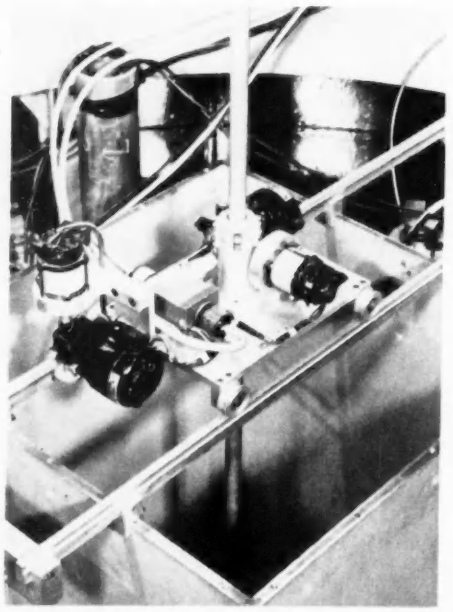


Fig. 9 Probe drive mechanism for flux-mapping instrument. It gives a two-dimensional plot (up and across) directly and the third dimension by changing the direction of the channel.

region in a horizontal line. From this a two-dimensional flux plot can be obtained. If the third dimension is required the channel can be set in the other direction. The miniature fission chamber developed by Smith and Nobles is generally used.

The reactor programme contains the following experiments for each particular core and blanket combination: 1. determination of the flux distributions throughout the entire reactor (the purpose of this is to discover the fission ratios in the different regions of the reactor and determine the reactivity balance of the two regions); 2. measurement of the prompt lifetime of the reactor by adding a l/v absorber to the thermal section; 3. spectrum measurements using nuclear plates, proton recoil, and lithium speck loaded plates (it is hoped that another type of spectrometer may prove successful, either a nitrogen or helium 3 filled proportional counter, a three-region recoil neutron spectrometer, or a cloud chamber, but there are difficulties inherent in each of these methods); and 4. studies of the fission ratios for different materials in the central region, the capture to fission ratio of uranium 238, the fuel worth in the central region; and the danger coefficient of various interesting materials. In the process of studying all these different properties it is hoped that enough data will be acquired to recognise whether or not a two region reactor of this kind is a practical power producing machine. The advantage of the two region reactor is that it has the kinetics of a thermal reactor and the breeding properties of a fast reactor. It also has a much lower fuel inventory than a fully fast reactor. The investigation may provide sufficient data on such a system to predict the behaviour of a mixed system when used as a power breeder reactor.

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ADJUSTABLE RACKS

Although designed primarily for the display of merchandise in shops, the Vizusell system manufactured in this country by Versatile Fittings (W.H.S.), Limited, 55 Fetter-lane, London, E.C.4, can well be used for any storage system. Basically, it consists of a system of upright metal channels, shaped to give T-slots, to which brackets are attached by a rectangular headed nut and a screw, the nut being trapped in the T-slot. Apart from ordinary shelf brackets, several different interchangeable forms are available for both horizontal and inclined fittings.

INDUCTION MELTING FURNACE

Mains Frequency, Coreless Construction

What is said to be the first mains frequency, coreless, induction melting furnace built in this country is now in use by International Combustion, Limited, at Derby. Built by Birlec, Limited, Tyburn-road, Erdington, Birmingham, 24, the furnace is of 5 tons capacity, and is rated at 300 kW. Basically, it is the same as the well-known high-frequency furnace, having a cylindrical melting chamber, lined with a rammed refractory material, and surrounded by a water-cooled helical copper coil. It is pivotally mounted at the front, and electrically-powered hydraulic tilting gear is provided for pouring purposes. An auxiliary petrol engine drive enables the hydraulic pump to be kept in operation in the event of a power failure.

The furnace is intended primarily as a holding and superheating unit, being fed with molten iron from cupolas, but it also has a useful melting capacity for dealing with cold additions. It enables a number of metallurgical operations to be carried out, and will be used particularly in the preparation of metal for the production of spheroidal graphite iron. Over a temperature range of 1,350 to 1,550 deg. C. the furnace has a superheating rate of about 5 tons per hour per 100 deg. C., with an approximate power consumption of 60 kWh per ton. The melting rate is approximately 8 cwt. per hour, with a power consumption of 670 kWh per ton. This latter figure may, at first sight, appear high, but as the furnace is designed primarily for holding and superheating and not for melting, the electrical input at 300 kW is small in relation to the furnace size. This reduces the melting rate and therefore increases the energy consumption per ton to be melted.

It is possible to superheat to over 1,550 deg. C. quite easily, the furnace itself imposing virtually no maximum temperature limitation; only the limit imposed by the chosen lining material has to be considered. The present furnace has a lining of high-silica refractory, rammed round a sheet-steel former which is melted out with the first charge. Experience has shown that when melting iron, with a pouring temperature nearing 1,500 deg. C., the lining life is approximately 150 heats.

The use of mains frequency current has reduced the number of electrical auxiliaries required, and the layout is quite a simple one. The furnace itself is mounted in a surrounding charging and working platform against the foundry wall, and the necessary substation is immediately behind the platform, outside the foundry proper. Control of the hydraulic tilting gear is from a desk on the platform, close to the pouring point, where the operator has a clear view of the furnace and the ladle which is being filled. Charging is by means of the foundry crane, which also handles the ladles for pouring. Electrical control is from an instrument panel at the rear of the working platform.

The installation runs on a low-tension supply of about 420 volts, which is fed to it through a contactor and an isolator. Mechanical interlocking between the isolator and the substation door and the entrance to the furnace excavation permits access to these points only when the power is off. The main on-load contactor is provided with overload protection, backed by high rupturing capacity fuses and an off-load isolator. The transformer is provided with tappings for a wide range of power inputs, giving any degree of superheating or melting up to the maximum. A reactor associated with a static balancer is provided in the same tank as the transformer to give a reasonably balanced three-phase load on the incoming supply mains. Coil power factor is corrected to unity by means of a bank of 50-cycle power-factor correction capacitors connected in parallel across the coil. They are housed in the substation.

Current is fed to the furnace from the busbars through water-cooled flexible cables, and coil cooling water is brought in by hoses. Monitoring relays cut off the power and give warning in case of inadequate water flow, and an emergency water supply protects the coil.

Similar in construction to the high frequency induction melting furnace, the new Birlec furnace operates at mains frequency, without a core.

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PNEUMATIC CONTROL VALVES

A basic unit, on the linear slide valve principle, forms the main portion of a comprehensive range of control valves now being manufactured by Midland Pneumatic Limited, New Cross, Wolverhampton. The valve consists of a body housing a simple balanced piston which traverses the valve slide across the lapped port face. The basic unit is arranged for four-way control with either positive, self-reversing or self-centring action. The last form is also available with its ports either blanked or open to exhaust in the neutral position. All four different types can be supplied for hand, foot, pad, mechanical, automatic or semi-automatic control, or in combinations of these various styles. The size range is from $\frac{1}{4}$ in. to $\frac{3}{8}$ in. British Standard pipe.

MICROWAVE BEACON FOR FISHING VESSELS

The Lorenz type of landing aid for aircraft has been adapted for marine work: the system will enable fishing craft too small to carry radar to enter harbour in bad visibility. When operating with this equipment the helmsman hears morse signals in his earphones. If he is to the left of the safe course of entry a V is heard (three dots followed by a dash). If he is to the right he hears a B (a dash followed by three dots). When the correct course is being steered he hears a continuous note.

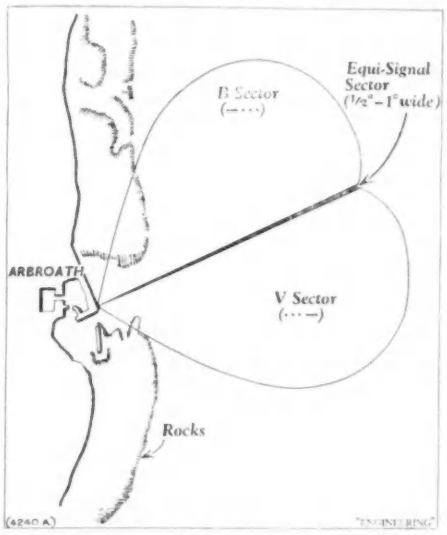

Fig. 1 The two sectors covered by the two aerials overlap, by about ¼ deg., on the course that is to be steered.

The transmitter operates on a wavelength of 3 cm. and two directional aerials are fed from it. The beams of each aerial cover an angle of 60 deg. and the two beams overlap by ¼ deg. A diagram of a typical installation appears in Fig. 1.

The output of the transmitter is switched in turn to each of the aerials in a manner that ensures that only one particular letter is broadcast in one sector. Thus only V is transmitted in the sector to the left of the safe course for an incoming ship, and only B is transmitted in the other sector. The characters of one letter are transmitted during the spaces of the other. The result is that a continuous signal is heard at the line of overlap of the two beams. The manner in which the transmission is divided between the two aerials is shown in Fig. 2. Any complementary morse letter such as A and N, or D and U, etc., may be used, but it has been found that letters with a large number of characters are more easily distinguished by unskilled operators. The maximum range of reception along the equi-signal zone, with the receiver at a height of about 15 ft., was found to be between 5 and 7 miles.

The equipment was developed for the Ministry of Transport and Civil Aviation. It is described in Admiralty bulletin number 85, prepared by Mr. A. L. P. Milwright, Mr. W. L. Dickinson, and Mr. A. Malein, of the Admiralty Signal and Radar Establishment.

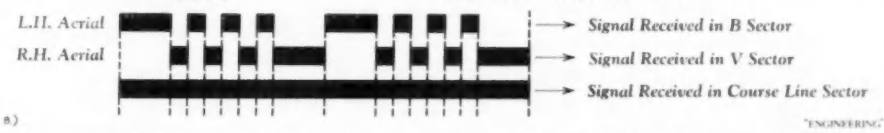

Fig. 2 The coding sequence is such that a character in one letter is being transmitted during the space in the other.

INDICATING SMOKE DENSITY

A recent installation of smoke density indicating and alarm equipment supplied by Radiovisor Parent Limited, Stanhope Works, High Path, London, S.W.19, has been developed to meet the requirements of B.S.2811. The layout of the boiler house flues at the Dulwich Hospital where the equipment is installed, the induced draught fan and an incinerator outlet, necessitated measuring the smoke at a common point on a brick stack in an exposed position. It was not possible to sacrifice any draught on the stack to clean the viewing windows of the equipment, and therefore both projector and receiver had to be fitted with a purging air blower.

The receiver, in its non-ferrous casing, is weatherproof and, once bolted in position, requires no further adjustment. In the projector unit, which is suitable for light beams up to 30 ft. long, there is a viewing aperture for use when focusing and aligning the direction of the beam. This eliminates the necessity for a separate spy-hole in the brickwork of the stack. A continuous stream of clean air from the blower passes over both viewing windows, preventing soot deposition but, in addition, both units are hinged so that their fronts can be reached for manual cleaning if necessary. The blower outlet is centrally placed between the projector and receiver, so that an equal supply is fed to both and the small quantity of air employed has no significant influence on stack temperatures. The amount is kept small by the use of large bore pipes and easy bends. The photoelectric receiver is connected to a control panel which incorporates a valve amplifier and an independent alarm circuit. In this way full deflection can be obtained on the indicator. An alarm pointer is fitted to the instrument as a guide to the boiler operator, together with indicating lamps. A permanent record is made on a strip chart recorder. There is also provision on the panel for supplying remote indicating meters if they are required. Calibration controls are included for both sensitivity and light beam length, so that the instrument can be calibrated in terms of percentage light obscuration or Ringlemann scale.

THIN-WALLED BEARINGS IN LARGE SIZES

The advantages of thin-walled plain bearings are now available to manufacturers of heavy engines and machinery, with the introduction by the Glacier Metal Company, Limited, Alperton, Middlesex, of a standard range of thin-walled bearings in bores from 6 in. to 12 in., in increments of ¼ in. up to 9 in. bore, and from 9 in. to 12 in. bore in increments of ½ in. The wall thickness is 0·142 in. in the lower range up to 8¾ in.; and 0·172 in. from 9 in. to 12 in. The maximum bearing width in all cases is 6¾ in., but can be increased by using two standard bearings side by side, with a gap between them forming an oil groove.

The bearings have a steel backing, and three alternative linings are available: (i) white metal; (ii) copper lead with an overlay of lead-base alloy of nominal thickness 0·0015 in.; and (iii) lead bronze with an overlay of lead-base alloy of nominal thickness 0·0015 in.

These bearings are made to close wall-thickness tolerances and are manufactured from strip material by a continuous process that lends itself to close control and consistent metallurgical quality. Other advantages claimed for thin-walled bearings are: (1) They are supplied pre-finished, i.e., to a wall thickness accuracy that enables them to be fitted without any machining or scraping. Fitting and assembly time is thereby greatly reduced. (2) The accurate bore size and contour results in better load distribution than can normally be obtained in practice from hand-scraped bearings. (3) Bearings can be replaced without special plant or skilled labour. (4) Spares are light in weight and are economical in storage space. (5) Their use in place of thick-walled shells frequently gives designers the option of increasing shaft sizes to carry greater loads without increasing the overall size of the assembly—or in the case of big ends, reducing the weight of the connecting rod assembly.

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BUILDING MATERIAL DATA

An information section to enable architects engaged on the London County Council's building projects to maintain themselves abreast of current developments in building materials and methods of construction, referred to in the technical Press, manufacturers' pamphlets and official and other reports, was established some years ago by the Council. This section, now called the Materials and Information Section and integrated, for organisation purposes, with the constructional divisions of the architect's department, is responsible for maintaining up-to-date reference data on constructional materials and methods and for making available full information on all new developments which might have a bearing on the Council's architectural work. The section also records on its files the building schemes on which new materials have been used, so that their subsequent efficiency or appearance may be known. Any defects which have been reported are recorded. A selection of samples of building materials and fabricated components are exhibited in a sample room. The advice and assistance of the section is available, moreover, to architects in private practice undertaking work for the Council.

The glasses of both the projector and receiver of Radiovisor's smoke-density indicator are kept clean from soot deposits by a small stream of purging air. Continuous indication of smoke density is given on the panel (inset).

THE FUTURE LIES IN HEAVY LORRIES

An Index of International Trade

The troubles of the motor industry during the past year have tended to conceal the lively progress made during that time by the builders of heavy vehicles. The Leyland and A.C.V. Groups, Atkinson, Guy, Fodens, Thornycroft and others have grown as never before in their history. Demand for heavy road transport is rising, and must continue to do so at an even greater rate. Of all the components of a rising standard of living, land transport is probably the most directly geared to the general trend. The immense advantages of modern heavy lorries over other methods—in operating costs particularly, and flexibility—ensure that they will increasingly become the favoured method of inland transport, whatever policies the railways, or Governments on the railways' behalf, choose to adopt.

ROAD TRANSPORT NOW PRECEDES INDUSTRIALISATION

Already the trend is fairly clear: in primary producing countries the laying of rails no longer precedes the advance of industrialisation, as was the case in this country, the United States and more recently in Latin America and Soviet Russia. Roads are one of the first claimants for investment, alongside agriculture, mining, port facilities and heavy engineering. India is a good example of this, as are many countries in the Middle East, Africa and now China. It is fairly plain therefore that investment overseas, now more urgent than ever in order to secure raw materials for the three major industrial centres of the world—North America, Europe and Soviet Russia—will mean more roads and more lorries to carry goods along them. The lorries will be for the bulk transport of building materials, fuels, agricultural produce, animals and the like. They will have to be ultra heavy with high-loading capacities and with mechanical strength equal to non-stop operation over poor roads and great distances. This is one of the most important points to grasp when considering the future of heavy vehicles. Like ships they must become available to carry materials to manufacturing industry. This is the first stage and will take place mainly in primary producing countries, now largely undeveloped, where rail networks are wholly inadequate to meet the land transport needs. The size of tanker, ore carrier and dry cargo programmes have surprised even the builders of these ships. Equally, the demand for heavy lorries from similar sources will tend to surprise the motor industries of the world. And yet the demand can be calculated on the basis of data which is freely available and more reliable than is the case for most other items of capital plant. In this respect heavy vehicle builders lag far behind their colleagues who build cars and light vehicles.

The second factor of major importance in the demand for heavy trucks is the increase in trade between industrialised countries with the consequent rapid increase in the demand for land transport. The third important factor is the need to supplement railway facilities in the transport of people. Western Europe is a good case in point. The plans of the International Roads Federation for a European network of highways linking all principal towns and industrial centres (see Weekly Survey last week, "Roads for Europe," page 358) are a useful starting point for building up an estimate. The growth of the number of vehicles of carrying capacities exceeding 10 tons (nothing less is really suitable for long-distance international transport) is another basis. The trends in inter-country trading are a third. The evidence under all these headings suggests that the demand for heavy trucks over the next decade will far exceed the capacity of the principal builders in this country and on the Continent. The following statement by Lord Derwent, chairman of the British Road Federation, in a letter to the Chancellor of the Exchequer is a useful commentary on the shape of things to come and their prodding effect on developments in this country: "I can assert with conviction that whatever the conception of a European free trade area may bring forth, modernisation of the road systems in the proposed participating countries is already proceeding at a pace and will continue to do so to a measure that will increase still further their competitive power." Lord Derwent said this in support of a plea for more and better roads for this country, but the evidence behind his words cannot lightly be brushed aside. To have good roads making possible the use of efficient long-distance vehicles is to acquire a position of advantage in competing with other countries. It is a development as inevitable as the next eclipse, and one which has major significance for the British builders of heavy vehicles.

The potential represented by passenger-carrying needs can be deduced from the published figures of coach and omnibus production. In 1935 it totalled 3,300 units, in 1956, 9,700 units. But the very advanced development of rail services in the United Kingdom, where traffic density is by far the highest in the world, tends to distort the general picture, as also do the generally shorter distances to be covered. Exports of buses in the past three years rose from 434 vehicles (1954) to 834, an increase of over 82 per cent. We would expect this trend to be maintained, and a major increase in the export of public transport vehicles to European countries over the next decade.

U.K. BUILDING CAPACITY

Recent statements by British heavy-vehicle builders confirm the contentions made above. Two units, Leyland Motors and Associated Commercial Vehicles, dominate the industry and probably account for over two-thirds of total output. The Leyland group, which includes Leyland, Albion and Scammell, have fixed assets worth some £12 million (at cost) and last year realised a trading profit of over £5½ million. This was over £1 million greater than in 1955 and a record for the company; it was based on a much increased turnover which is not disclosed but is unlikely to be much below £45 million. A.C.V.'s turnover rose by £2 million, and the marked growth in business over the past two years had led to a demand for capital which may have to be met by a public issue. A much smaller company, Atkinson Lorries, who made a trading profit of £141,000 for the year ending March, 1956, recorded an increase of 16 per cent. in the number of vehicles sold in the first six months of the current financial year, and a 20 per cent. increase in turnover. They, like their larger competitors, have found that demand is tending towards heavier-class vehicles. There is little doubt that it will do so increasingly. In this country a heavy tonnage of goods is transported in class C vehicles, the bulk of which are vehicles of lighter construction such as the Austin, Bedford, Ford and Commer trucks. Although the loading capacity of these vehicles extends to 7 tons they are not normally used for long-distance transport. The demand is for trucks able to carry 30 to 40 tons and so equipped that a crew of two (one sleeping in a couchette) can keep the vehicles moving without stopping. Loading times are reduced to a minimum by the use of tractor-trailer units, the trailers being preloaded and picked up by the tractor at scheduled times.

The extension of road transport in Europe, where attempts are being made to reduce frontier formalities, constitute a potential Leyland were quick to seize upon. The company have been exhibiting in Leipzig a number of buses and trucks which attracted a great deal of attention. The good performance and fuel economy of the British Diesel engine is an important asset, but it will doubtless be necessary to investigate the European markets in detail before firm conclusions can be drawn concerning the size and type of vehicles required. The general impression at present is that a rather larger and faster vehicle is required than is built by British firms and that this will become even more marked as progress is made in establishing a first-class international highway network.

The information available concerning the division of the British industry's output between medium and heavy vehicles is fragmentary. The industry is divided into two fairly distinct parts, one constituted by the volume producers, all of whom make light vans and trucks, such as Vauxhall, B.M.C., Ford and Rootes, and the other by the members of the British Transport Vehicles Manufacturers Association (BRITAVEMA). All the volume producers, but particularly Vauxhall and Rootes, make 7 to 8 ton trucks and single-deck buses. Britavema members also make this type of bus, but generally of heavier construction powered by a larger and slower-revving engine, though they also make trucks of less than 6 ton load-carrying capacity. It is estimated that they accounted for about 40 per cent. of the total output of trucks over 6 tons, i.e. some 10,000 vehicles in 1956 and two-thirds of the buses, i.e. 650 vehicles. The proportion of heavy vehicles, i.e. those over 10 tons, has been increasing in the past two years and is probably now about one-third of the total output of heavy trucks and half the output of buses. In 1956 they would therefore have amounted to some 3,500 trucks and 300 buses. Most of these heavy vehicles are powered by engines ranging from 130 b.h.p. to 200 b.h.p. On the Continent engines of 200 b.h.p. (naturally aspirated) are increasingly being used, and there is a tendency in this country also to go for an engine of greater capacity than has been the case so far. Engines of 15 litre have been developed by Leyland, A.C.V. and Meadows primarily for rail-car use, but may prove a popular power unit for heavy long-distance vehicles. On the Continent, Berliet, Henschel and Willeme are manufacturing naturally aspirated engines of 200 b.h.p. and there is a tendency to go even further. The use of super-charging has been resisted by hauliers for use over long distances but the progress made in the United States and in this country suggests that the higher horse-powers required may increasingly be obtained by supercharging or turbo-charging. It would enable the very heavy trucks to use engines developed for medium-load vehicles and produced in relatively large quantities—resulting in a much lower price per horse-power.

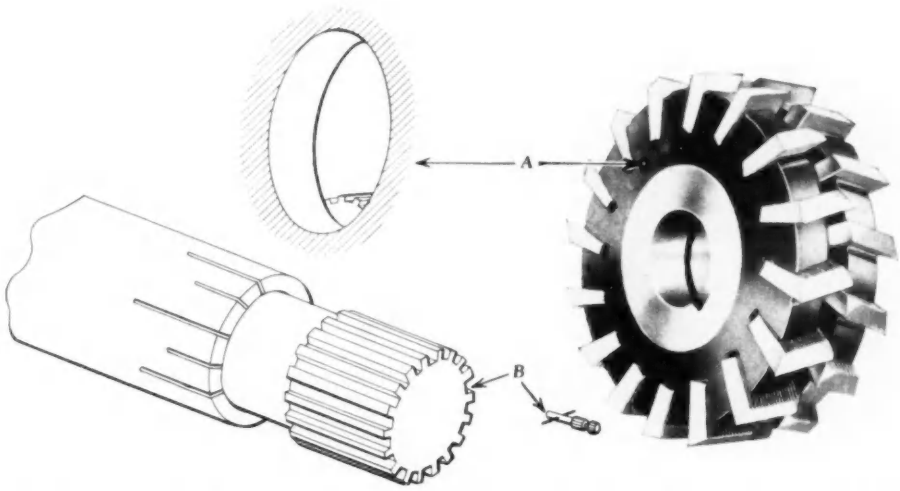
FREE TRADE IMPLICATIONS

A recent statement by the chairman and managing director of Leyland, Sir Henry Spurrier, shows both the company's awareness of the big opportunities that await British heavy-vehicle manufacturers on the Continent and also of the increased competition they must expect with the advent of the Common Market. He emphasised the importance of keeping to the forefront, as a primary object, "the need to design and produce a range of vehicles and units which would match any others in performance, quality and value for money."

Leyland look upon Britain's participation in a European free trade area as "the right road for this country" and Sir Henry expressed "a considerable measure of confidence" in his company's ability to compete. A study of the European market shows that though the demand for heavy long-distance vehicles is likely to exceed the capacity of manufacturers to supply them, no manufacturer is likely to become established unless he is able to provide a first-class spares and maintenance service. The operation of heavy road transport, particularly on international traffic, can be highly profitable but only if the vehicles can be kept on the road all the time. As the demand for carrying capacity increases, the present difficulties of the railways should become less marked and Governments can therefore be expected to decrease the protection afforded to railway undertakings. This would remove one of the major obstacles to

large-scale expansion of road transport and create a potential market in Continental Europe which British manufacturers should, by virtue of their size and scale of output, be able to supply better than most of their European competitors.

All in all, therefore, the prospects of the British heavy-vehicle manufacturers are good. They may become outstandingly so, as have those of the British shipbuilders, if they are able to seize their opportunities and build the types of vehicles required both in the under-developed countries of the world and in the industrialised countries of Western Europe. Present evidence, inadequate as it may be, points to the industry doubling its size in the next 10 years, but the facts need marshalling, trends must be analysed and in general the industry must equip itself commercially as well as it has done in its factories.



The Euco milling cutter spacer enables the width of a pair of cutters to be adjusted in 0·0005 in. steps without dismantling them from the arbor.

MICRO-ADJUSTMENT OF MILLING CUTTER WIDTH

Spacing Collars

An adaptation of the "Euco" micrometer spacing collar for gang milling has been introduced by Euco Tools, Limited, 44 London-road, Kingston, Surrey, for use in wide slotting or channelling.

It consists of a pair of interlocking cutters with a micrometer spacer between them. The outer collar of the spacer has a fine pitch gear on its periphery, and a key is provided, with teeth of matching pitch, to enable it to be turned from outside the cutter assembly. The arrangements of cutters, key and spacer can be seen in the illustration above. The key is provided with machine-divided markings, each division representing a movement of the cutters of 0·0005 in., while a complete turn opens or closes the cutters by 0·004 in.

A range of interlocking cutters with micrometer adjustment is available for all standard arbors, the blades being of high-speed steel, super cobalt high-speed steel, or Stellite or cemented carbide tipped as required. The minimum width of the inserted blade type of cutter assembly is $1\frac{1}{4}$ in., expanding to $1\frac{3}{8}$ in., but the principle is being applied to solid-type cutters, which it is anticipated will be available with minimum widths of $\frac{1}{2}$ in.

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PUSHING, PULLING OR INDEXING

Compressed Air Equipment

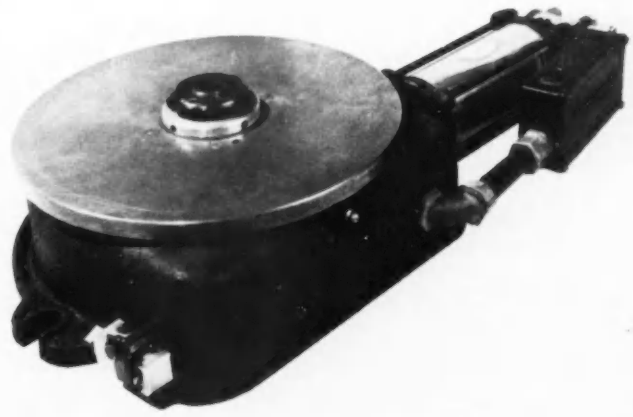
Three additions have been made to the British Bellows range of pneumatic equipment, manufactured under licence from the Bellows Company of U.S.A. by Geo. H. Hughes, Limited, Birmingham, 24, and distributed by Benton and Stone, Limited, Aston Brook-street, Birmingham, 6. These are: new methods of mounting the standard valve-air cylinder units, a heavy-duty "Hydrocheck," and a rotary indexing table.

The British Bellows valve-air cylinder unit is double-acting, and has the valve built into the cylinder end, as illustrated below. It has a bore of $2\frac{1}{2}$ in. diameter, and strokes of 1, 3, 6, 9 or 12 in. The valve can be controlled manually, by a remote air pilot valve, or by the Bellows "Electroaire" system, which enables it to be operated electrically. The Electroaire valve incorporates a very small solenoid, working off an 8 volt supply, which directs the main air supply to do the work of operating the valve. Suitable transformers for standard voltages are available. The new forms of mounting are by foot and front nose, by rear trunnion and by front flange. All the models in the range can be supplied with cushioned stroke at either or both ends, or without cushioning as required.

The Hydrocheck is a self-contained hydraulic cylinder designed for use with a pneumatic cylinder, to enable the piston speed to be controlled as required, the hydraulic check being effected by metering the oil through an adjustable needle valve. Several sizes and types of checking unit have been available for some time, and the new heavy-duty Hydrocheck increases the range. This model has a cylinder bore of $1\frac{3}{8}$ in. diameter, and a maximum loading of 2,500 lb. thrust. It can be fitted with a "skip" valve for allowing fast travel over any part of the stroke, with a stop valve to stop the movement at any part of the stroke, or with a combined valve which performs both functions.

Rotary indexing over an adjustable range of stations is possible with the British Bellows index table shown below. It has a table 10 in. in diameter, and a height of $4\frac{11}{16}$ in.; as the table is easily detachable, a larger one could be fitted if required. Indexing is by compressed air, the control being electric, working at 8 volts. A choice of five stations, 4, 6, 8, 12 or 24, is available, and the table can be set to any one by a rapid internal adjustment accessible through a removable side plate. Speed of operation ranges from 110 indexings per minute when set at 4 stations to 350 at 24.

(Above) The British Bellows combined valve-air cylinder is now available with several different methods of mounting.



(Right) A choice of indexing stations is available on the rotary index table, which is air-operated and electrically controlled.

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PUNCHED-CARD STANDARDS

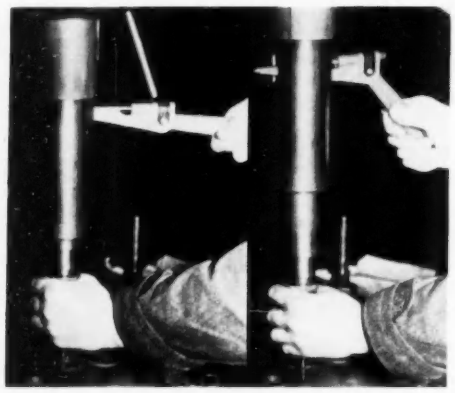
Punched cards are widely used in various branches of commerce and industry. In the factory, punched cards or punched paper tape are inserted in such machine tools as jig borers and planers to provide high-precision control. In the office, suitably punched cards or tape are fed into computers which then automatically work out particulars of employees' wages and similar calculations. To ensure that the blank cards or paper supplied by any one firm should fit into any punching machine and, subsequently, into any computer or machine tool, the British Standards Institution, 2 Park-street, London, W.1, have set up a committee to study the problems involved. The initial move for establishing standards for punched cards came from the Machine Tool Trades Association.

The committee includes representatives of all the major manufacturers of office accounting machinery; paper makers and printers; engineering and management associations; machine-tool makers and instrument manufacturers; the aircraft, automobile and electrical industries; big industrial organisations and the nationalised industries; government departments, universities, research associations and libraries. The committee has over 50 members and, because of its size, three sub-committees have been set up. The first will be concerned with the physical dimensions of cards, the second with evolving a standard form of coding, and the third exclusively with punched tape.

REMOVING TAPER-SHANK TOOLS

Ejection of drills and other taper-shank tools from the machine spindle is simplified by a new hand-operated drift introduced by Insley Industrial Supply Company, Limited, 21/22 Poland-street, London, W.1.

The operation of the drift is shown in the accompanying illustration. The point of the blade is inserted in the slot of the machine spindle socket, the handle being straight and in line with



Removal of taper-shank tools from the machine spindle is performed using only one hand with this expanding drift.

the blade. When the handle is pressed downwards it causes two cones within the blade to slide, and thus to cause an expanding action, which frees the taper-shank tool from the socket. As will be seen from the illustration, only one hand is needed to operate the drift, leaving the other hand free to support the tool.

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CENTRAL HEATING ECONOMIES

Hints on fuel economies that can be practised in oil-fired central heating plant were made in a lecture given by Mr. A. B. Pritchard of the Fuel and Oil Department, Shellmex and B.P. Limited. The lecture was presented at the London Building Centre.

Obviously the first requirement is that the fuel should be burned fully, and as much of the resulting heat as possible should be transferred to the circulating medium. The most common combustion efficiencies in actual practice range between 50 and 70 per cent., much below the capabilities of the plant. Incomplete combustion may result in the discharge of carbon as smoke, and can be checked with a smoke meter. One type draws a quantity of flue gas through filter paper, and the resulting stain is compared with standards.

The quantity of heat lost up the flue is a function of two factors, the temperature and the quantity of the gas. A stack temperature of 350 deg. F. and a minimum of excess air over that required for complete combustion is equivalent to a loss of about 13 per cent. of the total heat produced. The presence of more air, although at the same temperature, can double the heat lost. Therefore, all leaks should be sealed with asbestos rope or fireclay. They can be detected by lighted taper or by cigarette smoke. The proportion of carbon dioxide in the flue gases also measures the efficiency.

Very large savings can be achieved by heat regulation within the building; the minimum working temperature should be determined and not exceeded. A system of thermostats can see that it is maintained. Much heat is also lost by radiation and convection from pipe-work, and lagging should therefore be used wherever possible. Similarly, conduction through walls, floors and ceilings can be reduced by a layer of glass fibre or other insulating material.

NOTICES OF MEETINGS

Aslib

LONDON
"Availability of Atomic Energy Information," by R. M. Fishenden; and "The Needs of Librarians in Relation to Atomic Energy Information," by Miss J. Binns. Industrial Welfare Society, 48 Bryanston-square, W.1. Wed., April 3, 2 p.m. (Tea provided.)

Association of Supervising Electrical Engineers

LONDON
"Diesel Engines," by J. C. Barber. West London Branch. 134 King-street, Hammersmith, W.6. Tues., April 2, 7.30 p.m.
"Safe Use of Electricity," by S. J. Emerson. North London Branch. 677 Green Lanes, Harringay, N.4. Wed., April 3, 7.45 p.m.
CROYDON
Discussion on "Relay Control." South London Branch. Half Moon Hotel, Broad Green, Croydon. Thurs., April 4, 8 p.m.
GLASGOW
Discussion on "Manufacture of High-Voltage and Low-Voltage Cables and Their Uses." Glasgow Branch. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., April 3, 8 p.m.
ILFORD
"Timber Extraction in West Africa," by D. Allan. North East London Branch. Angel Hotel, Ilford. Mon., April 1, 7.30 p.m.
LIVERPOOL
"Servicing the Automobile Electrical Equipment." Liverpool Branch. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Fri., April 5, 7.30 p.m.
LUTON
"Physical Aspects of Electricity," by S. J. Emerson. Luton Branch. Chamber of Commerce, George-street West, Luton. Tues., April 2, 8 p.m.
MANCHESTER
Discussion on "Television as an Aid to Industry." Manchester Branch. Engineers' Club, Albert-square, Manchester. Wed., April 3, 7.30 p.m.

British Institution of Radio Engineers

GLASGOW
"Telemetry," by A. Cowie. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., April 4, 7 p.m.
MANCHESTER
"Electronic Control of Machine Tools," by H. Ogden. North Western Section. College of Technology, Sackville-street, Manchester. Thurs., April 4, 6.30 p.m.

British Interplanetary Society

LONDON
"History of Rocket Development in the Walterwerke," by Heinz Walder. Caxton Hall, off Victoria-street, S.W.1. Sat., April 6, 6 p.m.

British Nuclear Energy Conference

LONDON
"The Aqueous Homogeneous Reactor," by R. Hurst. Royal Institution, Albemarle-street, W.1. Tues., April 2, 5.30 p.m.

Building Centre

LONDON
Film on "The Control of Chimney Draught," exhibited by Omnia Constructions Ltd. Wed., April 3, 12.45 p.m.

Chemical Engineering Group

LONDON
"Some Applications of Statistical Control to the Chemical Industry," by A. G. Baker. Society of Chemical Industry, 14 Belgrave-square, S.W.1. Tues., April 2, 5.30 p.m.

Chemical Society

GALWAY
"The Chemical Revolution in Textile Technology," by Professor J. B. Speakman. Irish Republic Branch. University College, Galway. Mon., April 1, 7.45 p.m.
PORTSMOUTH
"Many-Centre Bonds," by Professor H. C. Longuet-Higgins. Southampton Branch. College of Technology, Anglesea-road, Portsmouth. Fri., April 5, 7 p.m.

Engineers' Guild

BRISTOL
"Problems and Prospects in British Air Transport," by P. G. Masefield. Western Branch. New Engineering Building The University, Bristol. Thurs., April 4, 6 p.m.

Illuminating Engineering Society

EDINBURGH
Annual Geueral Meeting. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., April 3, 6.15 p.m.
NEWCASTLE-UPON-TYNE
Annual General Meeting. Newcastle-upon-Tyne Centre. Department of Electrical Engineering, King's College, College-road, Newcastle-upon-Tyne 1. Wed., April 3, 6.15 p.m.
NOTTINGHAM
"Architects and the Illuminating Engineering Society's Code," by A. Buchanan Campbell. Nottingham Centre. Electricity Service Centre, Smithy-row, Nottingham. Thurs., April 4, 6 p.m.*

Incorporated Plant Engineers

LONDON
"Applications of Plastics in Industry," by Dr. C. L. Child. London Branch. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., April 2, 7 p.m.*
BOURNEMOUTH
"Industrial Diseases," by Dr. K. Biden-Steele. Southern Branch. Grant Hotel, Bournemouth. Wed., April 3, 7.30 p.m.
EDINBURGH
Films and Discussion on "The Generation and Use of Steam." Edinburgh Branch. Heriot-Watt College, Edinburgh. Tues., April 2, 7 p.m.

Institute of Marine Engineers

LIVERPOOL
"Practical Application of the 1952 Fire Appliance Rules," by G. Keenan. Merseyside and North Western Section. Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool. Mon., April 1, 6.30 p.m.

Institute of Metals

LONDON
Annual General Meeting. "Recent Developments in Electron Microscopy," by Dr. J. Nutting. London Local Section. Thurs., April 4, 6 p.m.*
OXFORD
Annual General Meeting. "Fatigue," by Dr. N. Thompson. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., April 2, 7 p.m.

Institute of Petroleum

LONDON
"Some Applications of Radioactivity in the Petroleum Industry," by J. L. Putman. Wed., April 3, 5.30 p.m.*

Institute of Refrigeration

LONDON
"Rapid Cooling of Meat in Germany," by Professor Dr. Ing. J. Kuprianoff. Junior Institution of Engineers, 14 Rochester-row, S.W.1. Thurs., April 4, 5.30 p.m.*

Institute of Road Transport Engineers

BATH
Annual General Meeting. Western Centre. Angel Hotel, Bath. Wed., April 3, 7 p.m.
CAMBRIDGE
Annual General Meeting. Eastern Centre. Lion Hotel, Cambridge. Tues., April 2, 7.30 p.m.
NOTTINGHAM
"Some Aspects of Vehicle Insurance and Accident Assessment," by A. G. Wright. East Midlands Centre. Mechanics' Institute, Nottingham. Wed., April 3, 7.30 p.m.

Institution of Chemical Engineers

LONDON
"The Aqueous Homogeneous Reactor," by R. Hurst. Royal Institution, Albemarle-street, W.1. Tues., April 2, 5.30 p.m.

Institution of Civil Engineers

LONDON
"Design and Construction of the Apapa Wharf Extension, Lagos," by D. C. Coode. Maritime and Waterways Division. Tues., April 2, 5.30 p.m.*
MANCHESTER
"Repair of Fire Damage at Skerryvore Lighthouse," by P. H. Hyslop and T. W. Moran. North Western Association.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Aslib (Association of Special Libraries and Information Bureaux), 4 Palace-gate, London, W.8. (KNIghtsbridge 0444.)
Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
British Nuclear Energy Conference, Great George-street, London, S.W.1. (WHItehall 4577.)
Building Centre, 26 Store-street, London, W.C.1. (MUSeum 5400.)
Chemical Engineering Group, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Engineers' Guild, 78 Buckingham-gate, London, S.W.1. (ABBey 7315.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, Manson House, 26 Portland-place, London, W.1. (LANgham 2250.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Designers, 38 Portland-place, London, W.1. (LANgham 8847.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Railway Signal Engineers, Euston House, Eversholt-street, London, N.W.1.
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds.
Liverpool Engineering Society, 9 The Temple, 24 Dale-street, Liverpool 2. (Central 3717.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Institution, 21 Albemarle-street, London, W.1. (HYDe Park 0669.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Engineers, 17 Victoria-street, London, S.W.1. (ABBey 7244.)
Women's Engineering Society, 25 Foubert's-place, London, W.1. (GERrard 5212.)

Engineers' Club, Albert-square, Manchester. Thurs., April 4, 6.30 p.m.

Institution of Electrical Engineers

LONDON
"Colour Television," by L. C. Jesty and Dr. E. L. C. White. Radio and Telecommunication Section. Mon., April 1, 5.30 p.m.*
Discussion on "The Teaching of Electrical Installation Subjects," opened by R. W. G. Ward. Education Discussion Circle. Tues., April 2, 6 p.m.*
"Electric Breakdown in Gases," by A. E. D. Heylen. London Graduate and Student Section. Wed., April 3, 6.30 p.m.*
Kelvin Lecture on "Infra-Red Radiation," by Dr. G. B. B. M. Sutherland. Thurs., April 4, 5.30 p.m.*
LIVERPOOL
Annual General Meeting. "Potentialities of Railway Electrification at the Standard Frequency," by E. L. E. Wheatcroft and H. H. C. Barton. Mersey and North Wales Centre. Royal Institution, Colquitt-street, Liverpool. Mon., April 1, 6.30 p.m.
LOUGHBOROUGH
"Power Amplifiers Used in Automatic Control," by J. V. Parry. East Midland Centre. Loughborough College, Loughborough. Tues., April 2, 6.30 p.m.
NEWCASTLE-UPON-TYNE
Faraday Lecture on "Nuclear Energy in the Service of Man," by Dr. T. E. Allibone. North Eastern Centre. City Hall, Newcastle-upon-Tyne. Tues., April 2, 7 p.m.
YORK
"Potentialities of Railway Electrification at the Standard Frequency," by E. L. E. Wheatcroft and H. H. C. Barton. North Midland Centre. Royal Station Hotel, York. Tues., April 2, 7 p.m.*

Institution of Engineering Designers

LONDON
"The Training of Engineering Draughtsmen and Designers," by C. Waldron. Thurs., April 4, 6.45 p.m.
BIRMINGHAM
"Turbo Car Progress," by P. A. Phillips. Queen's Hotel, Birmingham. Wed., April 3, 7.45 p.m.

Institution of Heating and Ventilating Engineers

LEICESTER
Annual General Meeting. East Midland Branch. Grand Hotel, Leicester. Wed., April 3, 6.45 p.m.

Institution of Highway Engineers

LONDON
"Improvement of Traffic Flow in Urban Areas," by Colonel S. Green. Institution of Structural Engineers, 11 Upper Belgrave-street, S.W.1. Fri., April 5, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Discussion on "The Need for Technologists in the Next Ten Years and How It is to be Met." Education Group. Tues., April 2, 6.45 p.m.*
"Modern Trends in Waterworks Pumping Machinery," by T. Irvine Hudson. Meeting in conjunction with the Hydraulics Group. Fri., April 5, 6 p.m.*
CHESTERFIELD
"The Rival Rail Traction Systems," by J. W. Caldwell. Joint meeting of the East Midlands and Yorkshire Branches. College of Technology, Chesterfield. Wed., April 3, 7.30 p.m.
MIDDLESBROUGH
"Economics of Plant Renewal and Replacement," by C. W. Griffiths. North Eastern Branch. Cleveland Scientific and Technical Institution, Middlesbrough. Tues., April 2, 6.15 p.m.
NEWCASTLE-UPON-TYNE
"Crankcase Explosions: An Investigation Governing the Selection of Protective Devices," by H. G. Freeston, J. D. Roberts and Dr. A. Thomas. Stephenson Building, Claremont-road, Newcastle-upon-Tyne. Thurs., April 4, 6.15 p.m.

Institution of Production Engineers

DUNDEE
"Automatic Control of Machine Tools," by A. G. Barton. Dundee Section. New Imperial Hotel, Tally-street, Dundee. Wed., April 3, 7.30 p.m.

Institution of Railway Signal Engineers

YORK
Annual General Meeting. Signalling School, Toft Green, York. Wed., April 3, 5.30 p.m.*

Institution of Structural Engineers

LONDON
Annual General Meeting and Film Evening. London Graduates' and Students' Meeting. Mon., April 1, 6.30 p.m.

Junior Institution of Engineers

LONDON
Film Evening. Fri., April 5, 7 p.m.*
BIRMINGHAM
"The Planning and Organisation of Capital Projects," by G. F. Wilkinson. Midland Section. James Watt Memorial Institute, Great Charles-street, Birmingham. Wed., April 3, 7 p.m.

Leeds Metallurgical Society

LEEDS
"Fatigue in Metals," by P. J. E. Forsyth. Large Chemistry Lecture Theatre, The University, Leeds. Thurs., April 4, 7.15 p.m.

Liverpool Engineering Society

LIVERPOOL
"Engineering Works at the Port of Liverpool," by R. A. Stephenson. Wed., April 3, 6 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"Graphical Presentation of Hull Frequency Data and the Influence of Deckhouses on Frequency Predictions," by Dr. A. J. Johnson and P. W. Ayling. Mining Institute, Newcastle-upon-Tyne. Mon., April 1, 6.15 p.m.

Reinforced Concrete Association

BIRMINGHAM
"Concrete Construction in the Soviet Union," by Dr. L. J. Murdock, W. J. Beckwith, Dr. D. D. Matthews and K. M. Wood. Midland Counties Branch. Birmingham and Midland Institute, Paradise-street, Birmingham. Tues., April 2, 6 p.m.*

Royal Aeronautical Society

LONDON
"Engine-Airframe Integration," by L. F. Nicholson. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., April 4, 6 p.m.*

Royal Institution

LONDON
"The First Transatlantic Telephone Cable," by Sir Gordon Radley. Fri., April 5, 9 p.m.

Royal Society of Arts

LONDON
"Spherical Perspective," by Brigadier J. L. P. Macnair. Wed., April 3, 2.30 p.m.

Society of Chemical Industry

NEWPORT
"Protection of Structural Steel Against Corrosion," by J. C. Hudson. South Wales Section. Technical College, Newport, Mon. Wed., April 3, 7 p.m.

Society of Engineers

LONDON
"Automation in the Motor-Car Industry," by E. Waddington Geological Society, Burlington House, Piccadilly, W.1. Mon., April 1, 5.30 p.m.*

Women's Engineering Society

LONDON
"Use of Electronic Computers in Engineering," by Miss Jill Robinson. 45 Great Peter-street, S.W.1. Fri., April 5, 7 p.m.*

ATOMIC REVIEW

A Few Golden Apples

IN endeavouring to keep up with the advancing front of knowledge, it is often necessary to by-pass items which may later prove indispensable to the coherence of our ideas. Even Atalanta's fleet suitor had to drop a few apples to stay ahead. Thus in Atomic Review we have often referred to current news concerning, say, fast reactors, without ever explaining what a fast reactor is; discussed criticality without indicating how it is determined; and described breeder reactors without defining breeding gain. Such questions may perhaps be taken in the stride, but when we come to read an article such as that on page 404, we may discover that the lacunae in our knowledge deprive us of full understanding; thus we hesitate over such words as "buckling" and possibly abandon the article altogether. Many words employed in reactor science can of course only properly be defined in mathematical terms, but to grasp their use in a particular context a broad explanation is often sufficient. A detailed mathematical treatment is naturally beyond the scope of Atomic Review, and the remarks below should be regarded not as definitions but simply as aids to understanding other notes and articles.

Critical Size

The critical size of a system or assembly of fissile and other materials is the minimum size necessary for a self-sustaining chain reaction to proceed. Since some $2\frac{1}{2}$ neutrons are produced per fission, and one at least must cause the fission of a second nucleus, not more than $1\frac{1}{2}$ may be lost either in non-fissile capture or outside the system. Thus in a steady state:

$$\text{production} = \text{absorption} + \text{leakage}.$$

Of the neutrons produced by fission reactions, the proportion lost from the system clearly falls as size increases, since the surface area (which governs the losses) is proportional to the square of the leading dimension, while the volume (throughout which neutrons are produced) is proportional to the cube. Thus as the size of the assembly is increased there comes a time when the system is just in equilibrium. (Criticality will of course never occur in a system where the neutron absorption per unit volume exceeds the neutron production.) At this point the system is said to be critical. The critical size depends not only on the mass of fissile material, but also on the nature, quantity and disposition of other materials present, and on the shape of the system. It should be noted that the effect of non-fissile materials need not be simply to absorb neutrons; the addition of a moderator or reflector, for example, may bring to criticality a system previously sub-critical. In the same way a piece of plutonium which in isolation is sub-critical may when brought adjacent to a cutting tool for machining become super-critical with unfortunate results. Criticality is also an important factor in designing chemical plants for processing fissile materials. The critical size for a sphere of pure uranium 235 or plutonium 239 is approximately the volume of a football, and the mass is about 100 lb.

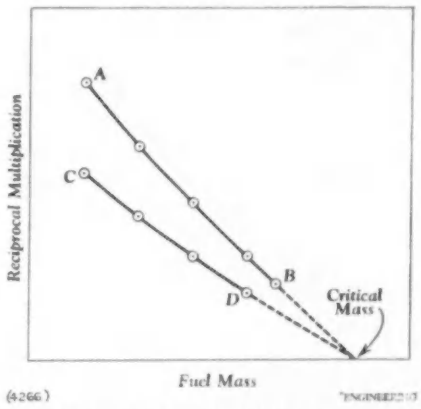


Fig. 1 Determination of critical mass by results obtained from a sub-critical assembly.

Critical Equation

Clearly critical size is a major factor in the design of nuclear reactors, and it is obviously important to be able to estimate the critical size of a given system before a full-scale reactor is constructed. In general, a theoretical calculation is first made and the result so obtained confirmed by experiments using sub-critical assemblies. The simplest calculation would be for a bare spherical reactor in which the fissile and non-fissile materials were homogeneously mixed.

It can be shown generally that for criticality

$$\frac{k\, e^{-B^2\tau}}{1 + L^2 B^2} = 1. \quad . \quad . \quad (1)$$

This is known as the criticality equation, where k is the infinite multiplication factor, or the ratio of the average number of neutrons produced in each generation to the average number of corresponding neutrons absorbed in a system of infinite size; τ is the Fermi age in sq. cm. (paradoxically not measured in units of time), a quantity related to the slowing down of neutrons in the given medium and in this case applying to thermal neutrons (see later section); and L the diffusion length in cm., or the mean distance travelled by a neutron from its source to the point at which it is absorbed. These three quantities, k, τ and L, are effectively specified by the (homogeneous) material contained in the system. (There is another important quantity k_{eff}, which is the effective multiplication factor, or the ratio of neutron production to absorption per generation, in a finite system, where losses outside the system, or leakage, is taken into consideration; thus if $k_{eff} = 1$, there is one neutron available per fission to continue the chain reaction, which is therefore self-sustaining. It is of interest that the Fermi age expression is analagous to that representing the transient conduction of heat in a continuous medium containing no sources.)

Buckling

B^2 in equation (1) is known as the "buckling" of the system and is so called because it is a measure of the bending or buckling of the neutron flux at any given point in the critical reactor. It is in fact a geometrical quantity dependent on the shape and size of the reactor, and can be obtained from the equation:

$$\nabla^2 \phi(\mathbf{r}) + B^2 \phi(\mathbf{r}) = 0 \; . \quad . \quad (2)$$

where ∇^2 is the Laplace operator, and $\phi(\mathbf{r})$ the neutron flux at a point having co-ordinate $\mathbf{r}$. From this equation the buckling for a sphere is shown to be equal to $\left(\frac{\pi}{r}\right)^2$ where r is the radius; for a rectangular parallelepiped

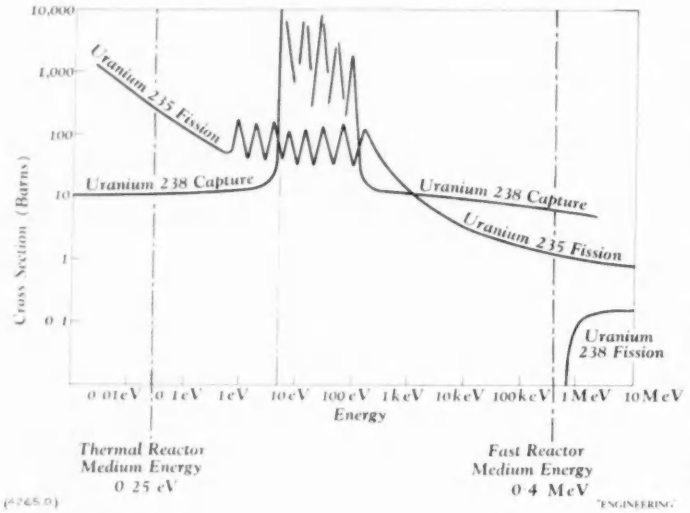


Fig. 2 (left) Simplified plot of uranium 235 fission and uranium 238 absorption cross-sections, showing thermal-neutron and fast-neutron regions. Scales are logarithmic.

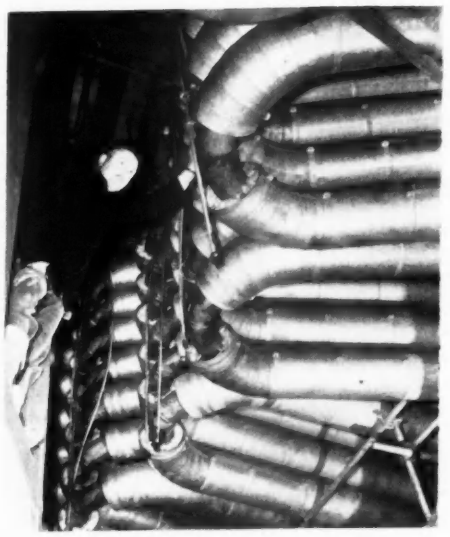


Fig. 3 (right) Part of heat-exchanger system for Dounreay fast reactor. The core of a fast reactor is necessarily highly enriched and hence small. The problem of heat removal is therefore severe.

$\left(\frac{\pi}{a}\right)^2 + \left(\frac{\pi}{b}\right)^2 + \left(\frac{\pi}{c}\right)^2$, where a, b and c are the rectilinear dimensions; and for a right cylinder $\left(\frac{2{\cdot}405}{r}\right)^2 + \left(\frac{\pi}{h}\right)^2$, where r is the radius and h the height. It follows, since the volume of a sphere is $\frac{4\pi r^3}{3}$, that the minimum critical volume for a sphere, is $130/B^3$. The corresponding values of minimum critical volume for a rectangular parallelepiped and a finite cylinder are respectively $161/B^3$ and $148/B^3$.

Thus if the materials of the system are known (so defining k, τ and L), the buckling, B^2, can be calculated from equation (1). Then, from equation (2) the minimum critical volume for any chosen core shape may be obtained in terms of the buckling. Conversely, given the size and shape, the characteristics of the core materials can be deduced.

Experimental Confirmation

Once the critical size has been theoretically determined, it is confirmed by experiment. A system of the chosen proportions and shape comprising fuel and moderator is built up until it approaches critical dimensions. At the centre of the assembly is placed a neutron source emitting about 10^7 neutrons per second. Owing to fission within the fuel, these primary neutrons are multiplied, and though the reactor is not in fact critical, a steady neutron flux will be achieved. The (sub-critical) multiplication may be defined as the ratio of the total thermal neutron flux, due to both primary source and fission, to the flux due to the source alone, and may be determined by thermal-neutron flux measurements in the fuel at a certain distance from the source, and at the same distance in the absence of the fuel. These measurements are made for various sizes of assembly and their reciprocals plotted against fuel mass as indicated by the line A B in Fig. 1. At the critical size, the neutrons from the artificial source might theoretically be reduced to zero but owing to the chain reaction the neutron flux in the reactor would still be finite and steady; thus the multiplication is effectively infinity and its reciprocal zero. Therefore, by extrapolating the line A B to the abscissa, the critical fuel mass may be obtained. A further line (C D) or lines may be drawn from measurements made at other points in the assembly as a check, and finally a critical reactor may be built to confirm that a chain reaction is sustained in the absence of an artificial neutron source. This approach is preferable in the case of small enriched-fuel reactors.

Exponential Experiment

A further method for determining the buckling and hence the critical size of a projected reactor is the exponential experiment, which is particularly suitable for larger assemblies, such as those using natural uranium. A sub-critical assembly is built having the same composition and structure as the proposed full-scale system, but with linear dimensions about a third or quarter of those anticipated. The assembly, which is preferably a cylinder of parallelepiped, rests on a base which comprises a constant source of thermal neutrons. This source may in fact be an existing thermal reactor, and the compound two-region system as described on page 404 is in some ways a development of this arrangement. Theoretically, the thermal-neutron flux in the z or vertical direction is given by

$$\phi(z) = Ce^{-\gamma z} \quad . \quad . \quad (3)$$

where C is a constant. This relationship, which holds at a reasonable distance from the source and the pile boundaries, indicates that the neutron flux falls off along any line parallel to the vertical axis in an exponential manner. Hence, the assembly is known as an exponential pile. From mathematical considerations it is apparent that $-\gamma$ is the slope obtained by plotting equation (3) logarithmically. From a consideration of equation (2), it can also be shown that $-\gamma^2$ may be substituted for the term representing the vertical dimension in the expression for buckling. Thus, if the horizontal cross-section of a parallelepiped reactor is given, then the buckling for the critical system may be obtained from

$$B^2 = \left(\frac{\pi}{a}\right)^2 + \left(\frac{\pi}{b}\right)^2 - \gamma^2.$$

Prompt and Delayed Neutrons

So far, we have been concerned with calculations for the steady state, when production and consumption of neutrons is in equilibrium. During start-up and shut-down other conditions apply, and certain factors assume special importance. Neutrons produced during fission are sometimes emitted promptly and sometimes after an interval. In steady-state operation this variation gives a constant average value for neutron flux, but in transient conditions allowance must be made for the delayed neutrons. A reactor is said to be prompt critical when it is critical on prompt neutrons alone.

Cross-Sections

Before discussing the fast reactor it is necessary to consider the concept of cross-section. The cross-section for a reaction is a measure of the probability that the reaction will occur in given conditions. It can conveniently be thought of as the area presented to an incident particle by another particle or nucleus, but also varies with the relative velocity of the two. Thus, reactions appear to be more likely when the particles are in each other's vicinity for a longer time, and generally the capture cross-sections are relatively high for reactions between nuclei and neutrons of low energy (slow neutrons). Indeed, in the slow-neutron region, the capture cross-section tends to decrease with increasing neutron velocity, so that cross-section is inversely proportional to v. This is the so-called $\frac{1}{v}$ law. Thus the cross-section of a target nucleus for any given reaction is a property of the nucleus and of the energy of the incident neutron. There are a considerable number of possible reactions, including scattering and various forms of capture. The unit of cross-section is the barn, which is the average "area" per nucleus presented to an incident neutron in units of 10^{-24} sq. cm.

Fast and Thermal Reactors

Fig. 2 is a sketch showing graphically the values of neutron cross-section for fission of uranium 235 and absorption in uranium 238. It should be emphasised that the graph, which has logarithmic scales, is much simplified and is only intended to illustrate the points given below. First, it can be seen that in the thermal region (median energy approximately 0·025 eV) the uranium 235 fission cross-section is much greater than that for capture in uranium 238. (Thermal is a term derived from kinetic theory denoting comparatively low energy values.) Thus, incident neutrons show a considerable preference for uranium 235, and the presence of uranium 238, even to the extent of 139 parts in 140 as in natural uranium, does not prevent a chain reaction from being self-sustaining. However, neutrons released on fission have energies averaging several MeV (actually ranging from quite low values to about 10 MeV), and to bring them down to the thermal region a moderator is necessary. Thus, all natural-uranium reactors require a moderator.

Now, in the region of 0·7 eV uranium 238 exhibits what is known as resonance capture and this extends, though to a lesser degree, up to about 200 eV. No reactor could conveniently operate in this region, not only because of instability but also because any uranium 238 present would tend to swallow all neutrons.

Beyond the resonance zone is the fast-reactor region (median energy about 0·4 MeV). Fast in this context refers, of course, to the energy of the neutrons. Here, as can be seen from the graph, there is preferential capture in uranium 238 and if a chain reaction is to proceed, the bulk of the uranium 238 must be eliminated. Thus all fast reactors use enriched fuels. It is interesting to note that in the region of 1 MeV, uranium 238 also undergoes fission. Since the fast reactor employs highly enriched fuel its critical size is small (if the core were made of pure fissile material it would, as stated above, be little larger than a football). Thus the problem of heat removal is severe, since much heat is generated in a small volume. In the Dounreay fast breeder reactor liquid sodium is used to carry away the heat, and some of the heat exchanger elements are shown in Fig. 3.

Breeding

Breeding, in reactor physics, is generally taken to mean the production of more fuel than is con-

sumed, in other words that the number of fissile nuclei obtained for each nucleus consumed (breeding gain) exceeds one. Fissile material is produced, for example, by neutron capture in uranium 238, which is thereby transformed after certain other changes into fissile plutonium 239. Similarly fissile uranium 233 may be formed from thorium. A conversion process of this kind occurs in natural uranium reactors, which are often in fact designed as plutonium producers; but since the breeding gain is here less than one, they are not generally regarded as breeders. Breeding is often, though not exclusively, associated with fast reactors, which have plenty of neutrons to spare and are normally built with a "fertile" (convertible material) blanket surrounding the fast core. Breeding gain in such reactors may exceed 1·5, and in the experimental fast reactor ZEPHYR at Harwell a gain of 2 has been achieved. The blanket is sufficiently remote from the fast section so as not to inhibit the chain reaction. Certain thermal reactors, such as those working on the thorium-uranium 233 cycle and liquid-metal fuelled reactors are believed to be capable of breeding gains greater than one.

It is of interest that if plutonium 239 is further irradiated it forms certain higher isotopes, some of which (Pu 242) are said to be readily fissile, and some (Pu 241) are not. Thus in the operation of natural uranium reactors, like those now under construction for the C.E.A., it is important that the period during which the fuel is in the reactor is such as to give the maximum benefit, with the minimum wastage of neutrons.

General Notes

Boiling Reactor for Germany

It has recently been reported that an order for a small atomic power station has been placed by a German company with Mitchell Engineering Limited, of 1 Bedford-square, London, W.C.1, and their American associates A.M.F. Atomics Incorporated, of New York. The station, which is to be built in the Ruhr for Rheinisch-Westfalisches Elektrizitätswerk A.G., will be based on the closed-cycle boiling-water reactor designed to produce steam at 900 lb. per sq. in. and 533 deg. F. (278 deg. C.) in the primary circuit. The secondary circuit will provide steam at 600 lb. per sq. in. and 489 deg. F. (254 deg. C.). The layout of the reactor system with its general features was described in ENGINEERING with a diagram on April 13, 1956 (page 220). The value of the order for the nuclear work is said to be 5·3 million dol. (nearly £1·9 million), of which about three-fifths will be earned in dollars by Mitchell Engineering for the construction of the reactor shell, heat exchangers and other reactor plant. The American firm will provide the reactor core and control equipment. The total cost of the station, which is designed to give an electrical output of 15 MW, has been estimated at just under £4 million. A site has not yet been chosen, but it is possible that an underground location may be selected.

An illustrated descriptive booklet has recently been published by Mitchell Engineering and A.M.F. Atomics describing the reactor offered by these companies, and its associated plant. It states that the reactor heat output is about 58 MW, and that the reactor core comprises 192 natural and slightly enriched uranium elements clad in zirconium or a zirconium alloy. A similar unit designed for installation at Elk River, Minnesota, on behalf of the Rural Co-operative Power Association, is to have a separately fired superheater giving a total output of 22 MW. The superheater is to supply about 20 per cent. of the total energy but increases the output by about 50 per cent. Fig. 4 shows the anticipated range of investment in a standard A.M.F. reactor, excluding fuel inventory. Fig. 5 represents fuel, maintenance and operating costs at 80 per cent. load factor. The advantage claimed for a superheater is indicated in Fig. 6, which gives results for three sizes of reactor.

Advantages of Boiling System

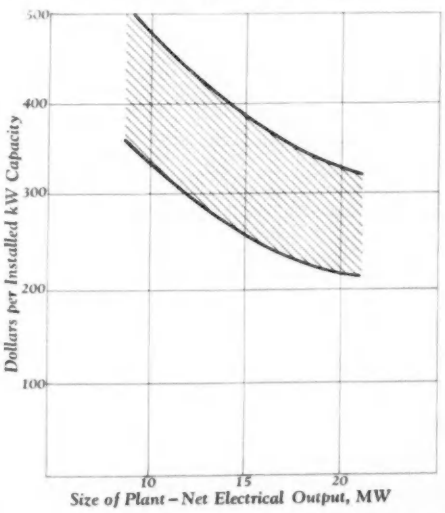
The advantages claimed for the boiling system are as follows. With liquid cooling the coolant occupies a smaller volume than is the case with gas cooling. Pressures are considerably lower than in the pressurised-water reactor (600 lb. per sq. in. as against 2,000 lb. per sq. in.). Although heat exchange is used in the A.M.F.-Mitchell reactor (so avoiding radioactive contamination of the turbine and other plant), this is not invariably necessary and the system can thus be very simple. Even with single-circuit designs the radioactivity of the steam can be kept so low that shielding the turbine is unnecessary. Reactors of boiling design can be made inherently safe by using the pressure in the reactor tank (when it exceeds a certain value) to blow the water down, so depriving the fuel elements of the water's moderating effect and stopping the reaction. On the other hand, steam formation in the reactor core also affects the moderating effect and leads to instability, a fault which has been attacked by divided-cycle techniques. A second disadvantage applies to all water-cooled or moderated reactors: radiation causes some dissociation of hydrogen and oxygen in the reactor, giving rise to serious corrosion problems. Nickel plating may be used to counter this defect. Other points concerning boiling-water reactors were made in Atomic Review on December 28 and November 23, 1956.

Radiological Protection Course

The fourth short course in radiological protection will be held at the Atomic Energy Research Establishment, Harwell, from April 29 to May 3 inclusive. The course, lasting 5 days, consists of lectures, demonstrations and practical work and is designed to give advice to people engaged in handling radioactive materials. It is expected that those attending the course will be graduates in a science or engineering subject and should have some knowledge of the principal facts concerning radioactivity. Inquiries should be addressed to the Isotope School, Atomic Energy Research Establishment, Harwell, Berkshire.

Inaugural Lecture

Speaking on "The Nuclear Power Programme and its Impact on Education," Professor J. M. Kay, in his inaugural lecture as Professor of Nuclear Power at Imperial College, drew attention to the parallel between the development of nuclear reactors and of steam engines. In passing, he referred to Sir Christopher Hinton's apprenticeship at Swindon and his own at Crewe. He also indicated that the gas-cooled graphite-moderated system had far to go; even now, according to the latest figures quoted by Sir Christopher, electricity could be generated from nuclear sources at a cost 0·733*d.* per kWh without credit for plutonium. If a plutonium credit of 0·070*d.* per kWh were allowed then the cost was 0·663*d.* per kWh, which in view of anticipated trends in coal prices, would very soon be competitive with power costs from conventional stations. In Professor Kay's view the nuclear fusion process would not, at least for some time, offer serious competition to the fission reactor. Fusion power, he said, would be very expensive. It appears therefore that there is a tendency for an increasing fraction of power costs to be contributed by the capital cost of equipment, and a smaller and smaller part by the fuel. With regard to advanced reactors—a term which he disliked, the gas-cooled reactor was as advanced as any—he pointed out that most of the novel systems, though superficially attractive, were as yet untried. It was, he said, more important to be successful than clever.



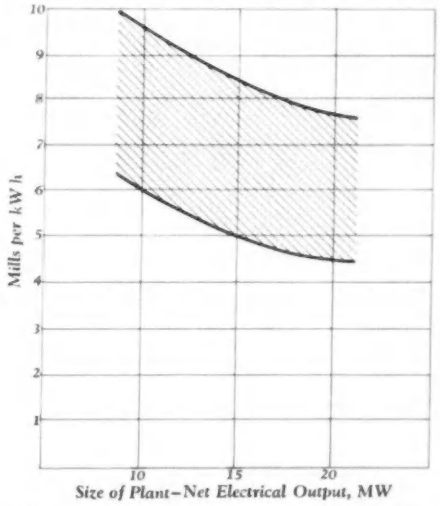
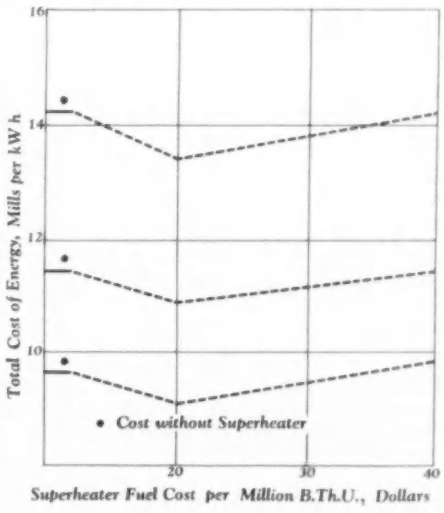


Fig. 4 (left) Expected range of plant investment in an A.M.F.-Mitchell closed-cycle boiling-water reactor electrical generating plant. The total cost includes land, reactor and steam generator, turbo-generator, electrical switchgear and buildings, but not fuel inventory.

Fig. 5 (above) Anticipated range of fuel, maintenance and operating costs for A.M.F.-Mitchell reactor plant. Fuel costs include consumption, fabrication, re-processing, plus 4 per cent. interest on fuel inventory, with station operating at 80 per cent. load factor.

Fig. 6 (right) Separately fired superheating of steam in reactor plants may reduce plant generating cost. This graph indicates the results of a study of a specific situation for three sizes of reactor. As the superheater fuel cost rises, the overall generating cost rises and eventually eliminates the advantage of the additional heating. Superheater efficiency assumed to be 85 per cent.; load factor at 80 per cent.



FORTHCOMING EXHIBITIONS AND CONFERENCES

This list, arranged chronologically, appears in the last issue of each month. Events appearing for the first time, and alterations of dates, places, etc., are indicated by an asterisk (*). Particulars of exhibitions and conferences not included below may have appeared in ENGINEERING, *January* 25, *page* 126; *or February* 22, *page* 254. *Organisers are invited to send to the Editor particulars of coming events as soon as arrangements are made.*

Industrial Textiles Fair, Second National—Mon., April 1, to Fri., April 5, at the Royal Albert Hall, Kensington Gore, London, S.W.7. Apply to Mr. V. G. Sherren, National Trade Press Ltd., Drury House, Russell-street, Drury-lane, London, W.C.2. Tel. TEMple Bar 3422.

Utrecht International Trade Fairs.—*Spring Fair:* Tues., April 2, to Thurs., April 11, at the Croeselaan Site, Utrecht. *Autumn Fair:* Tues., Sept. 3, to Thurs., Sept. 12, at the Croeselaan Site, Utrecht. *Agent:* Mr. W. Friedhoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

Planning for Industry: Midlands Conference.—Fri., April 5, to Sun., April 7, at Droitwich. Organised by the British Institute of Management, 8 Hill-street, London, W.1. Tel. GROsvenor 6000.

***Physics of the Solid State, Conference.**—Mon., April 8, to Wed., April 10, at The University, Nottingham. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

Electrical Industries Show, Fourth National.—Mon., April 8, to Thurs., April 11, at the 71st Regiment Armory, New York. Organised by the American Electrical Industries Exposition, Inc., 19 West 44th-street, New York, 36, U.S.A.

***Surface Activity, Second International Congress of.**—Mon., April 8, to Fri., April 12, in London. Apply to the honorary secretary of the conference, 14 Belgrave-square, London, S.W.1. Tel. BELgravia 3681.

Radio Component Show, 14th.—Tues., April 9, to Thurs., April 11, at Grosvenor House, Park-lane, London, W.1. Pre-view for overseas and special guests on Mon., April 8. Annual private exhibition organised by the Radio and Electronic Component Manufacturers' Federation, 21 Tothill-street, London, S.W.1. Tel. ABBey 4226. Applications for admission must be made in advance.

Chemical Engineering Education Symposium.—Tues, April 9, to Thurs., April 11, at The University, Birmingham. Organised by the Midlands Branch, Institution of Chemial Engineers. Apply to the secretary of the Institution, 16 Belgrave-square, London, S.W.1. Tel. BELgravia 3647.

Chemical Society's Anniversary Meetings.—Tues., April 9, to Fri., April 12, at Cambridge. Organised by the Chemical Society, Burlington House, Piccadilly, London, W.1. Tel. REGent 0675.

Electrical Engineers' Exhibition, Sixth.—Tues., April 9, to Sat., April 13, at Earl's Court, London, S.W.5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. Apply to Mr. P. A. Thorogood, Electrical Engineers (A.S.E.E.) Exhibition, Ltd., 6 Museum House, 25 Museum-street, London, W.C.1. Tel. MUSeum 3450.

British Photo Fair.—Thurs., April 11, to Wed., April 17, at Olympia, London, W.14. Apply to British Organisers Ltd., 52 Grafton-way, London, W.1. Tel. EUSton 7930.

London Audio Fair.—Fri., April 12, to Mon., April 15, at the Waldorf Hotel, Aldwych, London, W.C.2. Organised, on behalf of Audio Fairs Ltd., by C. Rex-Hassan and Associates, 42 Manchester-street, London, W.1. Tel. WELbeck 9111.

***Milan International Samples Fair, 35th.**—Fri., April 12, to Sat., April 27, at Milan. *Agent:* Dr. V. Schiazzano, 652 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 5521.

Saarbrucken International Samples Fair.—Sat., April 13, to Sun., April 28, in Saarbrucken. Organised by the Saarlandischer Gestalungskreis G.m.b.H., Saarbrucken.

United States World Trade Fair.—Sun., April 14, to Sat., April 27, at the New York Coliseum, New York. *Managers:* The Charles Snitow Organisation, Inc., 331 Madison-avenue, New York, 17. Information may be obtained from the British Commonwealth Chamber of Commerce in the United States, 677 Fifth-avenue, New York, 22; and from the Fair's British and Commonwealth Office, Dudley House, 36 and 38 Southampton-street, London, W.C.2. Tel. TEMple Bar 8947.

Molecular Mechanism of Rate Processes in Solids, Conference.—Mon., April 15, to Thurs., April 18, at the Royal Tropical Institute, Mauritskade, Amsterdam. Organised by the Koninklijke Nederlandse Chemische Vereniging. Apply to the Faraday Society, 6 Gray's Inn-square, London, W.C.1. Tel. CHAncery 8101.

***Practical Aspects of the Generation and Utilisation of Producer Gas.**—Tues. and Wed., April 16 and 17, at the Majestic Hotel, Harrogate. Organised by the British Coal Utilisation Research Association. Apply to the superintendent, Gas Producer Department, B.C.U.R.A., Randalls-road, Leatherhead, Surrey. Tel. Leatherhead 4411.

***Application of the Clean Air Act to Private Dwellings and Industry, Conference.**—Tues. and Wed., April 16 and 17, at the Queen's Hotel, Birmingham. Organised by the Combustion Engineering Association and the Solid Smokeless Fuels Federation. Apply to the Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. Tel. WHItehall 5536.

***Impact of Atomic Energy on Chemical Engineering, Symposium.**—Fri., April 26, at the Cora Hotel, Upper Woburn-place, London, W.C.1. Organised by the Graduates' and Students' Section of the Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. Tel. BELgravia 3647.

Lyons International Trade Fair.—Sat., April 27, to Mon., May 6, in Lyons. *Agents:* Robert Brandon and Partners Ltd., 47 Albemarle-street, London, W.1. Tel. HYDe Park 0901.

Swiss Industries Fair, 41st.—Sat., April 27, to Tues., May 7, at Basle, Switzerland. Information from the Commercial Attaché, Swiss Legation, 18 Montagu-place, Bryanston-square, London, W.1. Tel. PADdington 0701.

***Liège International Fair.**—Sat., April 27, to Sun., May 12, at Liège. Organised by the Foire Internationale de Liège, 17 Boulevard d'Avroy, Liège, Belgium. *Agent:* Mr. R. C. Liebman, 178 Fleet-street, London, E.C.4. Tel. CITy 5889.

***Brussels International Industries Fair.**—Sat., April 27, to Sun., May 12, at Brussels. Apply to the Fair Offices, Palais du Centenaire, Brussels.

***German Industries Trade Fair.**—Sun., April 28, to Tues., May 7, at Hanover. *Agents:* Schenkers, Ltd., Royal London House, 13 Finsbury-square, London, E.C.2. Tel. METropolitan 9711.

Materials Handling Exposition, National.—Mon., April 29, to Fri., May 3, in the Convention Hall, Philadelphia. Apply to Clapp and Poliak Inc., 341 Madison-avenue, New York 17.

Factory Equipment Exhibition, Fifth.—Mon., April 29, to Sat., May 4, at Earl's Court, London, S.W.5. Theme: "Greater Efficiency in Industry." Organised by Factory Equipment Exhibitions, Ltd., 4 Snow-hill, Holborn-viaduct, London, E.C.1. Tel. CENtral 0354.

Institute of Metals Spring Meeting.—Mon., April 29, to Sat. May 4, at the Church House, Great Smith-street, London, S.W.1, except May Lecture on April 29, which will be at the Royal Institution, Albemarle-street, London, W.1. Joint meeting with the Associazione Italiana di Metallurgia, the Société Suisse des Constructeurs de Machines, and the Schweiz. Verband für die Materialprufungen der Technik. Apply to the Institute of Metals, 17 Belgrave-square, London, S.W.1. Tel. BELgravia 3291.

Properties of Materials at High Rates of Strain, Conference on.—Tues., April 30, to Thurs., May 2, in London. Organised by the Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1, in collaboration with the Institution's Applied Mechanics Group. Apply to the secretary of the Institution at the above address. Tel. WHItehall 7476.

Health Congress.—Tues., April 30, to Fri., May 3, at Folkestone. Organised by the Royal Society of Health, 90 Buckingham Palace-road, London, S.W.1. Tel. SLOane 5134.

Metallurgical Aspects of the Control of Quality in Non-Ferrous Castings, All-Day Symposium.—Wed., May 1, at Church House, Great Smith-street, London, S.W.1. Organised by the Institute of Metals, 17 Belgrave-square, London, S.W.1. (Tel. BELgravia 3291); and the Institute of British Foundrymen, St. John Street Chambers, Deansgate, Manchester 3. Tel. Blackfriars 6178.

***Valencia International Samples Fair, 35th.**—Wed., May 1, to Mon., May 20, at Valencia. Apply to Feria Muestrario International de Valencia, Llano del Real 2, Valencia.

Lille International Fair.—Sat., May 4, to Sun., May 19, at Lille. *Agents:* Weigel, Leygonie and Co., Ltd., 31-32 Kingstreet, London, W.C.2. Tel. TEMple Bar 4825.

British Industries Fair.—Mon., May 6, to Fri., May 17, in the B.I.F. Buildings, Castle Bromwich, Birmingham. Organised and controlled by the Birmingham Chamber of Commerce. Apply to the organisers: P.O. Box 6, 95 New-street, Birmingham 2. Tel. Midland 5021.

Spring Show and Industries Fair.—Tues., May 7, to Sat., May 11, in Dublin. Organised by the Royal Dublin Society, Ballsbridge, Dublin.

***Instruments, Electronics and Automation Exhibition, First.**—Tues., May 7, to Fri., May 17, at Olympia, London, W.14. Promoted by the British Electrical and Allied Manufacturers' Association and four other trade associations. Organised by Industrial Exhibitions, Ltd., 9 Argyll-street, London, W.1. Tel. GERrard 1622. (Change of address of organisers.)

***Society of Naval Architects and Marine Engineers, Spring Meeting.**—Thurs., May 16, to Sat., May 18, at Lafayette Hotel, Long Beach, California, U.S.A. Headquarters of the Society: 74 Trinity-place, New York 6, U.S.A.

***Swiss Import Exhibition.**—Fri., May 17, to Sun., May 26, in the Hallenstadion, Zürich. Organised by the Schweizerische Import-Ausstellung 1957, Nordstrasse 20, Zürich, Switzerland.

***Electronics Exhibition, 12th.**—Sat., May 18, to Wed., May 22, in the Palais d'Egmont, Brussels. Organised by the Union Professionnelle des Fabricants et Importateurs de Materiel pour l'Industrie Electronique, 85 Boulevard Emile Jacqmain, Brussels.

***Swedish Industries Fair, 40th.**—Sat., May 18, to Sun., May 26, at Gothenburg. *Agents:* John E. Buck & Co., 47 Brewer-street, Piccadilly, London, W.1. Tel. GERrard 7576.

***Aeronautical Exhibition, 22nd International.**—Fri., May 24, to Sun., June 2, at Le Bourget, Paris. Organised by the Union Syndicale des Industries Aeronautiques, 4 Rue Galilee, Paris, 16e.

***Mediterranean Fair, 12th.**—Fri., May 24, to Mon., June 10, at Palermo. Apply to the Fiera del Mediterraneo, Piazza Generale Cascino, Palermo.

***Luxembourg International Fair, Ninth.**—Sat., May 25, to Sun., June 9, at Luxembourg. *Agents:* Auger and Turner Group Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

***Heating, Ventilation and Air Conditioning, Conference on.**—Mon., May 27, to Wed., May 29, at the Federation Nationale du Bâtiment, 7 Rue La Pérouse, Paris. Organised by the Institut Technique du Bâtiment et des Travaux Publics, 6 Rue Paul-Valéry, Paris, 16e.

***Chambers of Commerce of the Commonwealth and British Empire, 19th Congress.**—Week beginning Mon., May 27, at the Hall of the Worshipful Company of Fishmongers, London, E.C.4. Organised by the Federation of Commonwealth and British Empire Chambers of Commerce, 69 Cannon-street, London, E.C.4. Tel. CITy 4444.

Scaling-up of Chemical Plant and Processes, Symposium.—Tues. and Wed., May 28 and 29, at Church House, Westminster, London, S.W.1. Organised jointly by Het Koninklijk Instituut van Ingenieurs, De Koninklijke Nederlandse Chemische Vereniging, the Society of Chemical Industry (Chemical Engineering Group), and the Institution of Chemical Engineers. Apply to the Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. Tel. BELgravia 3647.

***American Society for Testing Materials, Annual Meeting.**—Sun., June 16, to Fri., June 21, at Chalfonte-Haddon Hall, Atlantic City, New Jersey, U.S.A. Organised by the American Society for Testing Materials, 1916 Race-street, Philadelphia 3, Pennsylvania, U.S.A.

***Institution of Civil Engineers, Conversazione and Exhibition.**—Wed., June 19, at the Institution building, Great George-street, London, S.W.1. Tel. WHItehall 4577.

***Welding and Cutting Exhibition and Conferences.**—Sun., June 23, to Wed., July 3, Exhibition on the theme of "Welding in Production and Application," at Essen. Tues., June 25, to Fri., June 28, Conference of the Deutscher Verband für Schweisstechnik E.V. (German Association of Welding) on the theme of "Improvement in Efficiency and Productivity by Welding," at Essen. Sat., June 29, to Sat., July 6, annual assembly of the International Institute of Welding, with symposium on "Metallurgy of Welding," at Essen. Apply to the Gemeinnützige Ausstellungsgesellschaft m.b.H. Norbertstrasse 2, Essen.

***Agricultural Fair, Sixth International.**—Mon., June 24, to Sat., June 29, at Utrecht. *Agent:* Mr. W. Friedhoff, 10 Gloucester-place, London, W.1. Tel WELbeck 9971.

Institution of Engineers and Shipbuilders in Scotland: Centenary Meeting.—Tues., June 25, to Thurs., June 27, in Glasgow. Apply to the secretary of the Institution, 39 Elmbank-crescent, Glasgow, C.2. Tel. Glasgow Central 5181.

***Electronics in Automation, Convention.**—Thurs., June 27, to Mon., July 1, at King's College, Cambridge. Organised by the British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. Tel. MUSeum 1901. (Dates arranged.)

***Automatic Production: Change and Control, Conference.**—Sun., June 30, to Wed., July 3, at Harrogate, Yorkshire. Organised by the Institution of Production Engineers, 10 Chesterfield-street, London, W.1. Tel. GROsvenor 5254.

***Atomic Exhibition, International.**—Mon., July 1, to Sun., Sept. 15, at Schiphol Airport, Amsterdam, Holland. *Agents:* Galitzine and Partners, Ltd., 17 Victoria-street, London, S.W.1. Tel. ABBey 4013.

***Physical Problems of Colour Television, International Symposium.**—Tues., July 2, to Sat., July 6, in Paris. Organised by the International Union of Pure and Applied Physics, the Société Française des Radioélectricians and the Société Française des Ingénieurs et Techniciens du Vide. Apply to the secretary, Colloque International sur les Problèmes de la Télévision en Couleurs, Conservatoire National des Arts et Métiers, 292 Rue Saint-Martin, Paris, 3e.

***Materials for Nuclear Engineering, Conference.**—Thurs. and Fri., July 11 and 12, at works of the Associated Electrical Industries Ltd., Aldermaston, Berks. Organised by the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

***Nuclear Physics Conference.**—Wed. and Thurs., July 17 and 18, in the Physical Laboratories, The University, Manchester. Organised by Professor S. Devons, F.R.S., under the auspices of the Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. Tel. KENsington 0048.

***Dornbirn International Export and Trade Fair.**—Fri., Aug. 2, to Sun., Aug. 11, at Dornbirn, Austria. Apply to the Export & Mustermesse Gesellschaft m.b.H., Dornbirn, Austria; or to the British-Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

***"Model Engineer" Exhibition.**—Wed., Aug. 21, to Sat., Aug. 31, at the New Horticultural Hall, Greycoat-street, London, S.W.1. Organised by *The Model Engineer* (Percival Marshall & Co. Ltd.), 19-20 Noel-street, London, W.1. Tel. GERrard 8811.

***Radio Show (24th Annual National Radio and Television Exhibition).**—Wed., Aug. 28, to Sat., Sept. 7, at Earl's Court, London, S.W.5. Préview for overseas and special guests, Tues., Aug. 27. Organised by the Radio Industry Council, 59 Russell-square, London, W.C.1. Tel. MUSeum 6901.

***St. Erik's Fair, 15th International.**—Sat., Aug. 31, to Sun., Sept. 15, in Stockholm. Apply to the manager, St. Erik's Fair, Stockholm 28.

Frankfurt International Fairs.—*Autumn Fair:* Sun., Sept. 1, to Thurs., Sept. 5, at Frankfurt. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

Leipzig International Fairs.—*Autumn Fair:* Sun., Sept. 1, to Sun., Sept. 8, at Leipzig. *Agents:* Leipzig Fair Agency in Great Britain, 127 Oxford-street, London, W.1. Tel. GERrard 0357.

***Sanitary Installation and Heating Technique Exhibition.**—Sun., Sept. 1, to Sun., Sept. 8, at Dusseldorf. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA) Ehrenhof 4, Düsseldorf, Germany.

***International Union of Geodesy and Geophysics, 11th General Assembly.**—Tues., Sept. 3, to Sat., Sept. 14, in Toronto. Held under the auspices of the International Union of Geodesy and Geophysics, 30 Avenue Rapp, Paris, 7e. Apply to the secretary of the Arrangements Committee for Canada: Professor J. A. Jacobs, Geophysics Laboratory, University of Toronto, Toronto 5, Ontario, Canada.

Cologne Fairs.—*Autumn Fair: Hardware and Household Goods:* Sat., Sept. 7, to Mon., Sept. 9; and *Clothing and Textiles:* Sun., Sept. 15, to Tues., Sept. 17, at Cologne. *Agent:* Mr. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

Vienna International Fairs.—*Autumn Fair:* Sun., Sept. 8, to Sun., Sept. 15, in Vienna. *Agents:* British Austrian Chamber of Commerce, 29 Dorset-square, London, N.W.1. Tel. PADdington 7646.

***Films in the Service of Industry, Festival.**—Tues., Oct. 8, to Sat., Oct. 12, at Harrogate, Yorkshire. Apply to the organising secretary, 3 Portman Chambers, 7 to 9 Baker-street, London, W.1. Tel. WELbeck 1104.

***Uses of Timber, Symposium on.**—Fri., Oct. 11, to Tues., Oct. 15, at Lodge Hill Residential College, Pulborough, Sussex. Organised by the Timber Development Association, 21 College-hill, London, E.C.4. (Tel. CITy 4771.) Apply to the regional officer, 8 St. George's-place, Brighton 1.

***Motor Show (42nd International Motor Exhibition).**—Wed., Oct. 16, to Sat., Oct. 26, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

***Factory Hygiene Medical Congress and Exhibition.**—Thurs., Oct. 17, to Sat., Oct. 19, at Düsseldorf. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA) Ehrenhof 4, Düsseldorf, Germany.

***Electric and Atomic Show, International.**—Fri., Oct. 18, to Sun., Oct. 27, at the Forum, Copenhagen. Organised by the Danish Electrical Development Association, Copenhagen, Denmark.

World Metallurgical Congress, Second; and 39th National Metal Congress and Exposition.—Sat., Nov. 2, to Fri., Nov. 8, in Chicago. Organised by the American Society for Metals, 7301 Euclid-avenue, Cleveland 3, Ohio, U.S.A.

***Measuring Instruments and Automation, International Congress and Exhibition (IKAMA).**—Sat., Nov. 2, to Sun., Nov. 10, at Düsseldorf. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H. (NOWEA), Ehrenhof 4, Düsseldorf, Germany.

***Industrial Efficiency and Productivity Exhibition.**—Tues., Nov. 5, to Sat., Nov. 16, at the City Hall, Deansgate, Manchester. Organised by Provincial Exhibitions Ltd., 167 Oakhill-road, Putney, London, S.W.15. Tel. VANdyke 5635.

***Smithfield Show and Agricultural Machinery Exhibition.**—Mon., Dec. 2, to Fri., Dec. 6, at Earl's Court, London, S.W.5. Apply to the exhibition manager, Smithfield Show Joint Committee, 148 Piccadilly, W.1. Tel. GROsvenor 4040.

In Parliament

LEARNING ABOUT ATOMS

As a result of his success in the ballot for notices of motion, Mr. Ben Parkin (Labour) was enabled to introduce a motion in the House of Commons last Friday welcoming the announcement of an expanded programme of capital investment in the production of power from atomic sources and urging that, in view of these developments, scientific and technical education at all levels should be expanded with the maximum speed.

It seemed to some Members, Mr. Parkin said, that the very announcement of the Government's programme involved a consequential re-assessment of the estimates of the needs of the country for scientists and technologists on which previous ministerial programmes of expansion had been based. He pointed out that while the Atomic Energy Authority required 10·9 per cent. of its employees to be qualified engineers and scientists, the Gas Council and area boards needed only 1·2 per cent. Aircraft manufacture required 1·9 per cent.; chemical and allied industries, 2·7 per cent.; and the electricity authorities, 2·9 per cent. It was already well-known that 60 per cent. of the research and development work done in this country as a whole was devoted to defence requirements. The impact of these and other industrial demands upon Britain's supply of engineers and scientists was obvious.

The problem of whether students were to be taught full-time or part-time, during the day or in the evenings, also needed a good deal of attention. Sandwich courses also needed a thorough re-examination. He felt that there could not be many more than 2,000 students taking these courses at present, which meant that the country was on the brink of a breakdown in the programme for these studies. The Government should look into the possibility of holding some sort of inquiry into the methods of teaching mathematics, not only in Britain but throughout the world.

MANY MORE SANDWICH COURSES

At this stage, Sir Edward Boyle, Bt., the Parliamentary Secretary to the Ministry of Education, drew attention to the fact that there had been an increase of more than 50 per cent. in the number of sandwich courses. He said that, in the academic year 1955-56 there were 103 courses, with 2,327 students taking part in them. He did not yet know the number of students for 1956-57, but there were now 169 courses.

Mr. Austen Albu (Labour), who seconded the notion, referred to the rate of emigration of some of Britain's valuable young people to the United States and Canada. In this connection, he suggested that, instead of trying only to improve its own level of production of engineers and scientists, Canada should make some contribution towards the expansion of Britain's universities and technical colleges, since Canada and such places were likely to secure quite a good proportion of their graduates. Another problem that might have to be faced was that local authorities would not be able to afford to finance colleges of advanced technology, particularly so under the Government's new system of a block grant.

The Government's plan, Mr. Geoffrey Lloyd (Conservative) pointed out, was to increase the supply of university students by some 60 per cent. during the next five years. It was expected that about two-thirds of these men and women would be scientists. That was a big programme. Part-time day releases began in 1921 and it might well be that the scheme was now outmoded. There was a need for a sandwich course of from two to three years' duration, leading to a national diploma for technicians. The very success of the atomic energy programme might be a danger to technological education, because its success was liable to lull the country into the feeling that there could be nothing wrong with technological education when such a magnificent feat, which, in Britain, was primarily a feat of applied science, had been accomplished.

The view was put forward by Mr. Richard Fort (Conservative) that what everyone wanted to see from Britain's schools of engineering was enough engineers of a high standard who eventually, with a few years' experience, would be able to exercise engineering judgment.

GOVERNMENT'S EXTENSIVE PROGRAMME

In his reply to the debate, Sir Edward Boyle said that, to a large extent, the new atomic programme would make demands upon ordinary engineering manpower. Some specialists required would need training in nuclear science and technology, to cope with particular problems in the erection of the power stations, and those engineers who operated the stations would also require to undertake special study. It was the aim of the Government to increase the yearly production of scientists and technologists from 10,000 to 20,000 during the next ten to fifteen years. They were doing their utmost to draw the attention of science graduates to the value of teaching as a career. Closer relations between the schools and industry were also being encouraged.

The universities, with the full support of the Government, had worked out plans for a radical expansion in their science and technology departments. Proposals had already been made by the universities for increasing the total number of their students from 84,000 in 1955-56 to about 106,000 by the mid-1960s. Of that increase, about two-thirds would be in the science and technology departments. For the current academic session, there were nearly 89,000 students.

A number of other Members took part in the discussion and the motion was accepted without a division taking place.

INTERNATIONAL ATOMIC ENERGY

Questions relating to recent developments in atomic energy were raised by Mr. William N. Warbey (Labour). He was informed by Mr. Ian Harvey, Joint Under-Secretary of State for Foreign Affairs, that, until the end of February, the United Kingdom was represented on the Preparatory Commission of the International Atomic Energy Agency by Sir Alec Randall. His place had now been taken by Mr. R. D. J. Scott-Fox, of the United Kingdom Permanent Delegation in New York, with Mr. M. I. Michaels, of the Office of the Lord President of the Council (Atomic Energy), as alternative delegate.

The Preparatory Commission had so far held twelve formal meetings. On March 4, a working committee of the whole assembled in New York, to discuss and make recommendations on the initial programme of the Agency. This committee had just completed the first stage of its work. It had been decided to hold the first general conference of the Agency in Vienna and the Preparatory Commission had tentatively settled upon August 19 as the target date for the opening of the conference. Her Majesty's Government had not yet ratified the Statute of the Agency, but arrangements would be made to deposit an instrument of ratification with the United States Government in accordance with Article XXI of the Statute as soon as possible after the statutory period was completed.

POWER STATION CONSTRUCTION

Later, Mr. Warbey urged Mr. Reginald Maudling, the Paymaster-General, to have an investigation made into the costings on which the contracts for the building of atomic power stations were based "in view of the wide disparity between the cost of approximately £145 per kilowatt installed capacity for the two stations ordered by the Central Electricity Authority and the station ordered by the South Scotland Electricity Board." This Mr. Maudling declined to do. He also refused to accept the implication contained in the latter part of Mr. Warbey's question, saying that, in their consideration of tenders, the electricity authorities could be relied on to carry out any cost investigations required.

Mr. Maudling said that the construction of the 19 nuclear power stations, announced in the Government's revised nuclear power programme, would not result in the cancellation of any contracts relating to the pre-existing development programmes of the electricity authorities for coal or oil-fired stations during the next five years.

EARNINGS PUSH PAST PRICES

A request was put forward by Major T. Beamish (Conservative) that the Minister of Labour and National Service should publish particulars of the average weekly earnings of adult male workers in the manufacturing industries during the last pay week for which the figures were available and for the corresponding week in the previous five years. He asked that details should be given showing how these earnings had increased as a percentage, counting the first figure quoted as a hundred, in comparison with the percentage rise in the cost of living since the same date.

In reply, Mr. Robert Carr, Parliamentary Secretary to the Ministry of Labour, supplied particulars, in tabular form, of the earnings of these employees for October in each of the years from 1951 to 1956, inclusive. For October, 1951, their average weekly earnings were £8 12*s.* 1*d.*, taken as 100, and compared with prices at that date, based on the retail prices index, also taken as 100. By October, 1953, average weekly earnings had risen to £9 16*s.* 7*d.*, equivalent to 114 per cent. of the figure of two years previously, while the level of prices had risen to only 109 per cent. For each of the succeeding years, the lead secured by wages over prices was continued at a rapidly-increasing pace. By October, 1955, earnings were £11 11*s.* 1*d.*, equivalent to 134 per cent., while prices had risen no more than 118 per cent. By October last, earnings had risen to £12 5*s.* 7*d.*, equivalent to 143 per cent., but prices were far behind, at only 122 per cent.

Sulphur Removal at Power Stations

Mr. Reginald Maudling told Dr. Somerville Hastings (Labour) that there were 49 power stations in the London Metropolitan Police District. Sulphur oxides, however, were removed from the flue gases only at Battersea and Bankside power stations. In 1956, the approximate percentages removed were 87 and 97, respectively.

Means Test for Research Scholars

An estimate of the savings resulting from the application of a means test to the winners of post-graduate research scholarships at universities was asked for by Mr. Ronald S. Russell (Conservative). In his reply to this, Sir Edward Boyle, Bt., said that the holders of State studentships for post-graduate awards in arts subjects and of comparable awards from the Department of Scientific and Industrial Research would not be subjected to a parental means test. He could not estimate the sums involved in taking account of the students' own resources, but they were likely to be small.

Deferments for Engineering Graduates

Mr. Harold Davies (Labour) questioned the Minister of Labour and National Service about the progress of deferments for engineering and science graduates. He asked if the Government's recently announced decision to grant deferment to science students securing a first-class honours degree this year and taking up employment in their scientific field, would apply equally to graduates who completed a research degree in science this year. Mr. Iain Macleod stated that the scheme for the deferment of men with first-class honours degrees in engineering and science, which he announced in December last, applied to students obtaining a first-class honours degree this year, and also to graduates completing a research degree this year who already held a first-class honours degree in these subjects.

THE HUMAN ELEMENT

Light in the Gloom

There was every prospect last week, that over one million engineering workers would be idle in addition to nearly a quarter of a million shipyard workers already on strike. An even greater threat developed when the National Union of Railwaymen scornfully rejected a wage tribunal award for a 3 per cent. increase in basic rates of pay. There could be no deeper gloom and certainly there had been nothing like it since the disastrous days of the general strike in 1926. Yet somehow, somewhere, a feeling of optimism had arisen.

The whole situation was unreal to a degree. Perhaps it was that nobody, union men or employers, really believed that the differences between the two sides warranted action which threatened the whole nation's livelihood, the competitive position of industry and the well-being of millions of people. In 1926 the Government were pursuing a ruthless policy of deflation and the strike was the desperate act of desperate men fighting for bread and potatoes. Now it is in fact over a few per cent. increase in basic wage rates, for there is no reason why industry should not keep wages in line with the cost of living and few good arguments for not giving workers a share in increased productivity. The unions ask for 10 per cent. but would almost certainly take 4 or 5 and the employers—down to the least efficient—would gladly pay 3 or 4. This is no ground for national strikes and everyone is realising it. It is the disproportion of the action to the cause which brings hope of a quick settlement.

Offers being made by non-federated firms in the engineering industry show that the will to pay more is present, particularly among those who set no great store by national agreements. After all, many of these companies who are leaders in their field already pay substantially above the agreed basic rate. Those who can't, owe this inability to compete to their own inefficiency, and in a boom it is easy and comfortable to be complacent—and this applies to the men as well as to the managements. But it carries a grave danger, of rising tempers, precipitate action, loss of ground overseas, falling profits and conditions which would make full employment a receding dream. It is because all knew this that a solution was, in fact, desired.

The Unknown Variable

Finding a formula to settle a dispute has become the favourite Westminster parlour game. Ever since Mr. McLeod, Minister of Labour, brought the Briggs strike to an end by getting the company to pay a man for non-attendance, a steady flow of suggestions has poured in. Even Mr. Bevan came up with the proposal that instead of an arbitrator, negotiations (in the shipbuilding industry) should be resumed in the presence of a " neutral observer who would make recommendations."

The rail dispute is the most real of the three. The tribunal's award was lower than the B.T.C.'s offer—rather in the style of an Appellate Judge feeling cross with the plaintiff. The N.U.R. say it is ridiculous to tell men that they can have no share in increased productivity until the organisation is " out of the red." Doubtless, they would argue that the Commission cannot do what they like and quote the Cameron report, that " having willed the end, the nation must will the means "—as did the dissentient member of the tribunal. The settlement reached over the week-end for a 5 per cent. increase has now set the pattern for the remainder of the industry.

Increasingly, as disputes proceed, the need for a " productivity " as well as a cost of living index becomes an important part of industry's armoury. But to compile it, taking into account investment in machines as well as the effort and applied skills of the workers, would be a difficult task.

Scalpel at the Throat

The doctors are taking a tough line with the state. Last week every general practitioner in the country received a letter from the British Medical Association calling him to resign from the Health Service next October unless the Government make a satisfactory pay offer or agree to arbitration. Taking a leaf out of the A.E.U.'s book, the Association say resignations should be " initially in selected areas."

Like other wage disputes this springs from the Eden Government's price freeze policy, now as dead as a dodo. Procrastination over the doctors' claims reached proportions that would never have been tolerated by an engineering trade union. But even though they have good cause, the nature of the threat does no credit to the medical profession's leaders. It is a threat directed far more at the nation's health than at the Government's policies. Accusations of bad faith over the Spens recommendations will get no-one very far. The facts are that in a prosperous period the doctors are worse off than before the war. Something will have to be paid for the greater security offered to all under the N.H.S., but not a blank cheque

Iron Discipline in Russian Coal

Conditions in Russian coal mines shocked British miners and impressed specialists of the National Coal Board who toured and inspected Russian coal mines last year. Two reports published recently throw a most revealing light on Soviet ruthlessness and enterprise.

A delegation of union leaders, led by Mr. W. E. Jones the president of the N.M.U., were aghast to find women doing heavy work: " It made us feel extremely embarrassed to see such heavy body-straining tasks being undertaken by women." They found working conditions very poor, housing appalling and the standard of living generally very low. They also found that " the people generally were working to the point of great strain to improve standards " and that mechanisation and industrial production were not allowed to lag.

The N.C.B. mission also remarked on the " relatively low standard of living " and on the high status and many privileges of officials compared to workpeople in their charge. On the other hand, they pay tribute to the lavish scale of education and training. Some 4,000 graduates and 13,000 technicians " approaching the British H.N.C. standard " enter the industry each year. They found also " ready acceptance of stern discipline " and the evidence of rapid progress, much scope for improved mechanisation and immense coal reserves.

Proper Studies

" It is idle to suppose that we have to-day sufficient teachers of scientific subjects." These words were spoken by the chairman of the Engineers' Guild, Mr. E. W. Greensmith, in an outspoken address given in Manchester last week. In support of his charge that the lack of science teachers was a threat to Britain's survival as an industrial nation, Mr. Greensmith quoted the report of a team from British engineering institutions on a visit to Russia, where the supply of suitable teachers and students is assured because " engineering has been made one of the most attractive careers of the country."

Outlining the efforts of the Guild to " bring about conditions in which engineering is accepted at its proper value by society," he stressed the need to make engineers' prospects at least equal to those of their United States colleagues. Expensive buildings, elaborate equipment and even scholarships will not secure the necessary doubling of the number of professional engineers needed during the next 13 years " if Britain is to survive as an industrial nation."

Fortunately for Britain, the Minister of Education, Lord Hailsham, is a great enthusiast and can be relied upon to extract the maximum investment in education from his colleague at the Exchequer. His speech last week at the Avery Hill training college for teachers, at Woolwich, was a stimulating expression of his faith: " To-day we aim at a general education for all. . . .Nothing short of this will ensure the survival of our system of Government." This, as well as the technical education he supports no less than Mr. Greensmith, is the country's best insurance policy in Mr. Macmillan's " opportunity State."

Bustle isn't Business

Productivity for pattern makers depends not so much on working harder but on a better knowledge of mathematics and geometry, with an understanding of drawings and modern equipment. The general president of the United Pattern Makers Association, Mr. Ellis Smith, M.P., analyses the main factors which contribute to greater productivity in pattern making in an article published in the March issue of the Association's monthly report.

Mr. Smith challenges the contention that the best way to get more output is to work harder. To work more intelligently is, in his view, far more to the point: " Don't mistake bustle for business " is a slogan which could be usefully posted in every pattern-making shop. He also attacks overheads which, he says, distort the general picture of pattern-making productivity. His article is based on a book entitled *Dynamic Factors in Industrial Productivity*, by Mr. Seymour Melman, and contains useful statistics quoted in support of his arguments. It is encouraging to find this attitude, so strongly in favour of method study and improved techniques, in a union magazine.

Catalytic Characters

A fascinating and warmly human study of the roles of the shop steward and the foreman has been made by Mr. Ferdynand Zweig, and is published in the January issue of *Occupational Psychology*, the journal of the National Institute of Industrial Psychology. In an article of eight pages, Mr. Zweig makes a bigger contribution to understanding of the industrial climate than has been produced by a long succession of courts of inquiry, arbitration, and the like.

The profile of the shop steward is unique: he is described as " one of the most interesting, dramatic and constantly evolving figures in the modern works community." His function is quite vital—he is a catalyst for men's real grievances, frustrations and aspirations. In a good atmosphere he is unnoticed; in one where management is poor he becomes a thorn in the flesh. He has many problems and difficulties and " to understand his troubles with sympathy is half the battle."

The foreman is " the crucial and most important figure in production, and the key to work satisfaction and good labour relations." His function is complex, his status is being attacked and slowly eroded by the trend of specialisation of labour. And yet he is " the classical example in modern times of the paramount importance of combining the technical need for specialisation with the human need for integration."